EARLY SCIENCE
IN CAMBRIDGE

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BY

R. T. GUNTHER, M.A., Hon. LL.D.

Curator of the Oxford Museum of the History of Science

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COWLEY'S ANSWER TO AN INVITATION TO CAMBRIDGE

NICHOLS, *my better self, forbear,*
For if thou tell'st what Cambridge *pleasures are,*
The School-boys *sin will light on me,*
I shall in mind at least a Truant *be.*

Why do I stay then? I would meet
Thee there, but Plummets hang upon my feet:
'Tis my chief wish to live with thee,
But not till I deserve thy company.
Till then we'l scorn to let that toy,
Some forty miles, divide our hearts:
Write to me, and I shall enjoy,
Friendship, and Wit, thy better parts.

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THE EXHIBITION OF HISTORIC SCIENTIFIC APPARATUS IN THE OLD SCHOOLS, JUNE 1936

PREFACE

THESE notes have clustered round a fairly complete list of the scattered Scientific Instruments which have been closely associated with various phases of research and teaching in the University of Cambridge, and with the spread of scientific culture in the provinces.

Many of these instruments are doubtless obsolete, some have never attained to great scientific importance, yet, in the absence of other more suitable material, they are worthy of preservation. They have a definite national value as milestones in the history of English Science, and are not infrequently found to contain germs of suggestions for useful development. Most have the merit of rarity and of association with the great men of science of other days.

The Preservation Society of Cambridge has recently expressed the hope that means may be found to preserve the finer houses and park-lands associated with the landed estates of the country. May not advantage be taken of this spirit of preservation, which is so characteristic of the present age, also to secure for the service of posterity the permanence of the Memorials of Science, and, if possible, in an orderly arrangement for the instruction of students?

The great national Museums in London have increased far beyond what a man can assimilate in a lifetime. Galleries crowded with objects derived from varied sources confuse a wearied visitor. Cambridge has the power of making a more telling appeal if she will but suitably stage the work of her own members, and so revive a side of history that has been intimately interlinked with that of her opposite number in Oxford, for many centuries before the newer Universities came into being. The members of these Universities too, whether at home or overseas, would

welcome such a display, for a proper use of the instruments of Science is not confined to a single township: it is for the common weal of the whole civilized world.

It has been my personal privilege to have been permitted to handle and examine instruments used by Newton, Cavendish, Wollaston, Young, Clerk Maxwell, the Darwins, and a score of others whose illustrious names make British science honoured. This book is a humble acknowledgement of so great a trust. That its obvious imperfections may prove an incentive to others to dig deeper into the records of bygone sciences and their votaries is the ambition of the compiler.

It gives me great pleasure to acknowledge the facilities which all owners of old instruments in Cambridge were good enough to give me when preliminary surveys and lists were being made in 1934. Without the access readily granted by the Professors of the Scientific Departments and by the Librarians of the several Colleges, I could have done nothing.

But especially thanks are due to the Council of the Cambridge Philosophical Society, and more particularly to the Members of the Committee appointed by that Society, to Professor A. Hutchinson (Chairman), Professor Stratton, Dr. Hamshaw Thomas (Secretary), Dr. Cockcroft, Professor Newall, Professor Rideal, and Mr. P. Dee.

On their application the University, in June 1936, granted the use of the fine East Room in the Old Schools for a Loan Exhibition of Historic Scientific Instruments. This room, formerly part of the University Library before its removal across the Cam, had been newly decorated, and its fine proportions and lighting went far to secure the success of the Exhibition.

About one-third of the items listed in this book were exhibited, and thus public attention was drawn to scientific wealth stored in unexpected places. If the manuscript material in the University and College Libraries had been as freely drawn upon, the illustration of the early Science of Cambridge would have been still more complete.

To the numbered lists of the Instruments I have added extracts from very various sources. In compiling these historical notes I felt that I should do little more than

obscure the pictures which specialists have painted were I to attempt to reproduce them in my own colours and with a less perfect knowledge and execution. Beyond the assemblage of out-of-the-way notes which chance has brought to light, no attempt has been made to suggest their relative bearing or importance. Many gaps have been filled from the large works of reference well known to Cambridge writers, but not usually on the shelves of students of the Natural Sciences. Among others J. Willis Clark's *Architectural History of Cambridge*, Cooper's *Athenae*, *Annals*, and *Memorials*, the incomparable *Reminiscences* of Gunning, Munk's *Roll of the College of Physicians*, and Venn's *Alumni Cantabrigienses*. No historian can do without reference to such authorities. Nor can the specialist write without the works of Whewell, Shipley, Clark-Kennedy, Sir Humphry Rolleston, and many another.

In addition to such sources of information open to all, I have been privileged to publish extracts from hitherto unpublished manuscripts of Richard of Wallingford in the University Library; of Dr. Heberden in St. John's Library; of John Ray, thanks to Sir William Campion; of Sir Thomas Sclater, thanks to Mrs. Ruck-Keene; and of several others, for all of which thanks are tendered to their respective owners.

The greater number of illustrations are the result of the technical skill of Mr. W. Tams. These have been supplemented by loans of blocks from the Cambridge University Press, from Sir Humphry Rolleston's *Cambridge Medical School*, from Pembroke College, from the Ray Society, and from Mr. E. Savile Peck. The figures on, or facing, pages 128–9, 150, 184–6, have been reprinted from the author's *Astrolabes of the World* and *Early Science in Oxford*. Professor Nuttall, Dr. Needham, and Mr. R. S. Whipple have contributed information which is acknowledged in the text.

R. T. GUNTHER.

MUSEUM OF THE HISTORY OF SCIENCE,
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INTRODUCTORY

The earliest references to the very first foundation of our two ancient Universities are so delightfully vague, that neither has had any difficulty in proving its superior antiquity to the satisfaction of many. It is perhaps more dignified to exorcize all spirit of rivalry, and to proclaim the history of both as lost in the mists of antiquity. At no time has the one not benefited by the existence and prestige, and sometimes by the troubles of the other.

For instance, it was as early as A.D. 1209, was it not, that Cambridge received students who were forced to leave Oxford owing to disputes with the townsmen there? And history repeated itself in 1240; but nine years later an affray in Cambridge resulted in many of the students returning to Oxford; and in 1261 a similar affair caused yet more to leave, some for Oxford, but others for Northampton. In 1264 the Northampton contingent returned to their Alma Mater.

Of a truth, in the thirteenth century sweet were the uses of adversity in knitting even Oxford and Cambridge together.

'The Universitie of Cambridge', wrote William Harrison in 1577, 'is distaunt from London about 46 myles north and by east, and standeth very well, saving that it is somewhat low & neere unto the Fennes, whereby the holsomnesse of the ayre there is not a little corrupted. It is excellently well served with all kindes of provision, but especially of fresh-water fish and wildefowle, by reason of the Isle of Ely which is so neere at hande. Onely woodde is one of the chiefe wants to such as studdie there, wherefore this kind of provision is brought them either from Essex & other places thereabouts, as is also their cole, or

otherwise the necessity thereof is supplyed with gall, and sea-coole, whereof they have great plenty lead thither by the Grant. Moreover it hath no such store of medowe grounde as may suffice for the ordinarie expences of the towne and Universitie, wherefore they are inforced in lyke sort to provide their haye from other villages about, which minister the same unto them in verye great abundaunce.

'Oxford is supposed to containe in Longitude 18 degrees and 28 minutes, and in Latitude 51° 50 min.; whereas . . . Cambridge standing more northerly hath 20 degrees 20 min. in Longitude, and thereunto 52 degrees and 15 minutes in latitude, as by exact supputacion is easy to be founde.'

How wild the country was is shown by the following description of the neighbourhood of Royston which had a great reputation as a 'nature reserve' in the seventeenth century, and in consequence of the destruction of its rural amenities King James I made a special order for its preservation. The preamble to the commission states:

'Insomuch as at our late coming unto Royston, and the parts thereabout for our recreation, we have found our game of partridge and pheasant so decaied that the countrie thereabouts could yield us no sport in that kinde: Wee taking the premises into our consideration, and knowing right well that our well affected subjects are and will be so farre from the spoile and destruccion of our game, as they will with all dutiful readynes further the increase thereof, with forbearance of their owne delight for our disport, as a speciall means of the preservacion of our health, and therefore deeming that the said spoile and destruccion have been occasioned out of the insolence of audacious and irregular persons, that so little esteeme our laws and commandments, are resolved for the time to come, to withstand and punish such boldness and contempt, and especiallie and particularly in the parts near unto Royston, wherby wee hope hereafter to receive more recreation and delight at our usuall residence there.'

When travelling across the well-tilled acres of modern Cambridgeshire, especially when the land is yellowing with harvest after a successful summer, it is difficult to realize how poverty-stricken was the countryside in the time of Charles II.

'As we rode along', wrote Baskerville in 1681, 'we saw here and there some poor cottages and wretched farms where some poor souls at a wretched rate do weather out a winter to look after the cattle that feed there. But doubtless there is incomparable fowling to make those amends that will undertake that pleasant toil, for the Red Shanks and other birds were very tame. In this passage between the ale-house and Ely we saw many Jacks sunning in the ditches between the highway and the enclosures.'

The lower lands were perfect paradise for fish and fowl. The popular etymology of the name 'Ely' is obvious.

Many another passage might be quoted from ancient writers to show that Cambridge was no ordinary place in olden days. For instance it is said that in the summer of 1640 the river Cam became red as blood, and the water being taken up in basins retained the same colour, and that many strange sights were seen in the air, as armed men fighting—a presage of troubles to come!

And on August 3 of the same year we read that 'This night there was great thunder and lightning (the like thunder was never heard by old men now living) together with hail, rain, and winde.'[1]

Like her sister University, Cambridge has been most happy in her ichnographer. In 1690 David Loggan of Dantzig, whose name is a hall-mark of accuracy, published a collection of engravings of all the University buildings and Colleges, that for truth of detail have never been surpassed.

Biography was provided for by a record of the *Lives of Illustrious Cambridge Men* in two volumes compiled by Morris Drake Morris, who died in 1720. And, of course, now there is the incomparable work of Venn.

Trade in 1763

For an account of the more important material necessities of life we may turn to an early guide-book for 1763, named *Cantabrigia Depicta*.

'Nor is it better supplied with water than with the other Necessaries of Life. The purest Wine they receive by way

[1] Worthington, *Diary and Correspondence*, ed. Crossley, i. 8.

of Lynn; Flesh, Fish, Wildfowl, Poultry, Butter, Cheese and all manner of Provisions, from the adjacent country: Firing is cheap; Coals from Seven-pence to Nine-pence a bushel; Turf or rather Peat, four shillings a Thousand; Sedge, with which the Bakers heat their Ovens, four shillings per hundred Sheaves; These together with Osiers, Reeds and Rushes used in several Trades, are daily imported by the River Grant. Great Quantities of Oil, made of Flax-seed, Cole-seed, Hemp and other seeds, ground or pressed by the numerous Mills in the Isle of Ely, are brought up this river also; and the Cakes after the oil is pressed out, afford the Farmer an excellent Manure to improve his Grounds. By the River also they receive 1500 or 2000 Firkins of Butter every week from Norfolk & the Isle of Ely, which is sent by Waggons to London: Besides which great Quantities are made in the neighbouring Villages, for the Use of the University & Town and brought fresh to Market every day except Monday. Every pound of this butter is rolled and drawn out to a Yard in Length about the thickness of a walking-cane; which is mentioned as peculiar to this place. The fields near Cambridge furnish the Town with the best Saffron in Europe, which sells usually from 24 to 30 shillings a Pound.'

Roads and Communications

Trade demanded communications, especially with London and the port of Lynn. And so does, we may add, the import and export of students to and from the University.

On 9 March c. 1628, by Royal Proclamation, common carriers were prohibited from going or travelling on common highways with any cart or carriage having above two wheels, whereupon the University petitioned on behalf of 'their trusty and ancient carrier', Thomas Hobson, that a 'toleration might be procured for him, for it is impossible for him to carry from us to London those great vessels of fish for provision for his Majesty's household; secondly the passengers, whereof most are scholars, women, or children, that travel to and from in them; thirdly books, trunks and other necessaries for our scholars ,without danger of overthrowing, and great loss and spoil . . . [all] which cannot

possibly be undertaken in carts, without greater charge and inevitable danger, the ways being deep in winter, and the carts more subject to overthrowing, and so spoiling the owners' goods, and endangering the lives of those that pass in them.' In 1630 Hobson, who had been Cambridge Carrier since 1596, died at the age of 86. A token was struck in 1799.

A good story used to be told of Dr. Henry Harvey, who as Master of Trinity Hall made a Causey for about 3 miles from Cambridge towards Newmarket. A certain nobleman greatly (but unjustly) suspecting the Doctor's inclination to Popery, and meeting him one morning as he was seeing his workmen, said: 'Doctor, I imagine you think this Cause-way is the Highway to Heaven.' 'No, no, Sir' was the reply, 'for then I should not have met you in this Place.'

On 31 July Thos. Witherings was empowered to reorganize the Inland Posts. It was to be arranged that the Edinburgh mail should be put into a 'portmantle' in London, and that on passing Cambridge a bag should be dropped with letters to be delivered by a foot post.

One experienced traveller, presumably about 1662, took care to be independent of the uncertainties of the inns on the road. He was a Fellow of Catharine Hall, Dr. Thomas Goodwin by name. 'In his travil he caryed blankets, linning, neats-tongues, claret, etc, in his coach, as Mrs. Arrowsmith told Mr. Woodcock when ye Dr. lay at Trinity College.' Dr. Goodwin was afterwards made President of Magdalen College, Oxford, and died in 1679.

In these days of congested streets and of noisy traffic it may be permitted to an Oxford man to think yearningly of 1662 when at 'Cambridge, unlike Oxford, the Colleges are not surrounded with the offensive embraces of Streets, but generally situated on the outside, affording the better convening of private Walks and Gardens about them'. (Fuller.) The distinguished foreigner, Professor Alberti of Hanover, visited Oxford in 1750, and naturally being desirous of seeing Cambridge also, found that there was no means of doing so without returning to London and thence taking coach for Cambridge. It was therefore well for any intending visitor to be accurately informed as to the Posts, &c., from London.

'An exact List of the Posts, Coaches, Stage-Waggons and other Carriers' printed in *Cantabrigia Depicta* for 1763, pp. 111–17, shows that the Post to London set out on Mondays, Wednesdays, and Fridays at 5 p.m., passing through Royston, and returned on Tuesdays, Thursdays, and Saturdays at noon. Also on Tuesdays, Thursdays, and Sundays at 6 p.m. through Walden, returning on Sundays, Wednesdays, and Fridays.

A Fly for 4 passengers started at 7 a.m. and arrived at the Queen's Head in Gray's Inn Lane at 5 p.m. A Stage-coach for 6 persons at 10*s*. each, and a Stage-coach for 4 passengers at 10*s*. each, also made the journey on 3 days a week.

Lynn Passage-boats left on Tuesday mornings, returning on Sunday.

The first Cambridge mail-coach started running on 6 February 1792. It performed the journey in $7\frac{1}{4}$ hours and then went on to Wisbech (*C.C.* 19 January, 12 May 1792).

On 25 May 1822 the following exciting notice was put up in the town:

'Zachariah Whitmore of Philadelphia, North America, begs to inform the inhabitants of Cambridge that he intends starting from Lynn on his Water Velocipede at 12 o'clock, and will arrive at Cambridge between 6 and 7 o'clock in the evening on Whit Monday next.'

Accordingly on Whit Monday about 2,000 persons assembled—but after several hours discovered that they had been hoaxed. But in 1824 and 1825 a steam packet plied between Cambridge and Lynn, making two voyages either way each week.

Travel by Air

The last two decades of the eighteenth century saw the first experiments in travel by Air.

On 22 March 1784 Mr. Astley (the riding master from Westminster Bridge) launched from Emmanuel College Close two air balloons, the one four feet, the other sixteen feet in circumference: the larger one was up 35 minutes, and fell near Cherryhinton; the smaller rose to a great height, and after floating for an hour and ten minutes fell

near Chesterton sluice (*Cambridge Chronicle*, 20 and 27 March 1784).

On Nov. 21 of the following year Mr. Poole, accompanied by a Mr. John Armstrong, ascended in a balloon from Trinity Hall Close. They remained up for an hour and five minutes, and descended at Wickhambrook in Suffolk (*Cambr. Chronicle*, 26 Nov. 1785, 17 Dec. 1791).

Green's Balloon Ascents

1827, October 19, with G. W. Scott of Trinity College from a close at the back of the Manor House opposite Jesus College. Descent in meadow 3 miles west of Chatteris.

1829, May 19, with two members of the University from Warwicker's Yard Barnwell to parish of Grendon near Wellingborough.

1830, May 8, Mr. Green jun. with R. Holland C.C.C., T. W. Hulkes St. John's from Warwicker's Yard Barnwell to parish of Standground near Peterborough.

May 15 with Dr. Woodhouse, Caius, J. Ackers and F. W. Beaumont, Trinity, from Warwicker's Yard to Branches Park in Suffolk.

1831. May 16 Mr. Green junr. with R. Holland C.C.C. and T. F. Turner of St. John's, from Warwicker's Yard to the London and Huntingdon Road near Papworth Hall.

1832. May 16 Mr. Green jun. with a relative and James Hope of St. John's Coll. from Warwicker's yard to Foulmere.

May 19 Mr. G. junr. with Heywood (Trinity) and Clarke (St. John's) to Graveley.

1838. June 28 Coronation Day at 6.30 Mr. and Mrs. Green ascended in a balloon which descended near Fulbourn.

1847. Mr. Green, ascended from Parker's Piece in his balloon on July 6 on the occasion of the visit of Queen Victoria and the Prince Consort.

Railways

In the early part of 1825 a railway from Bishop's Stortford to Cambridge was projected by a company called the London Northern Railroad Company.

At a public Meeting held on 27 September 1834 Mr. N. W. Cundy, C.E., explained his plan for a railroad from London to Cambridge and thence to York. It was to be called 'The Grand Northern and Eastern Railway'. It

was estimated that the part from London to Cambridge would cost £900,000 and could be completed in 18 months.

Next year on November 14 at a public Meeting with Christopher Pemberton in the Chair, resolutions were passed approving of Mr. James Walker's proposed line of railway from London to Cambridge and York and from Cambridge to Norwich and Yarmouth.

On 4 July 1836 royal assent was given to an Act for making a Railway between London and Cambridge, with a view to its being extended thereafter to the Northern and Eastern Counties of England.

This Railway was to commence near Frog Lane, in the parish of Islington, and to proceed thence through Hackney, Stoke Newington, Tottenham, Ponder's End, Waltham Cross, Cheshunt, Broxbourn, Stanstead Abbots, Roydon, Harlow, Sawbridgeworth, Spelbrook, Hockerill, Bishop's Stortford, Stanstead Mountfitchet, Elsenham, Newport, Wendon, Chesterford, Whittlesford, and Shelford, to Trumpington, where it was to terminate, near the River Cam, by Edleston's Farm House. By an Act passed 19th July, 1839, the Northern and Eastern Railway Company were empowered to deviate from the above line in the parish of Tottenham, and to form a junction with the Eastern Counties Railway at or near Angel Lane, in Stratford. By another Act, passed 4th June, 1840, the Northern and Eastern Railway Company were empowered to abandon the line from Hockerill to Trumpington. By another Act, passed 31st May, 1843 powers were given to extend the Railway from Hockerill to Newport. By another Act, passed the 23d May, 1844, the Northern and Eastern Railway Company were empowered to lease their railway to the Eastern Counties Railway Company, who, on the 4th July, 1844, obtained power to extend the Railway from Newport, by Cambridge to Ely, and thence eastward to Brandon, and westward to Peterborough. (Cooper, iv. 601.)

In 1837 five railways schemes were proposed, but none was carried into effect. The projected routes were:

1. Cambridge, by Whittlesey and Peterborough to York—[by the Northern and Eastern Railway Company].
2. Cambridge to Tring—[by Mr. Cruikshank].

3. Cambridge, by Newmarket, to Bury St. Edmund's.

4. The Cambridge Transverse Railway from Cambridge, eastward to Newmarket and Bury St. Edmund's; and westward to St. Ives, Huntingdon, Thrapston and Kettering, to Market Harborough, there to join the projected South Midland line to Northampton and Leicester.

5. The Grand East and West Junction Railway from Cambridge, by Caxton, St. Neot's, and Bedford, to Newport Pagnell, there to join the London and Birmingham Railway.

Two railway projects were mooted in 1841.

1. From Clerkenwell by Ware, Barley, Melbourn, Thriplow, and Shelford to Cambridge and thence by Crowland and Lincoln to the Great North of England Railway at Nether Poppleton in the West Riding.

2. The 'East Anglian Railway' from Bishop's Stortford by Wendon, Chesterford, and Shelford to Cambridge and thence to Newmarket, Thelford, Attleborough, and Norwich to Yarmouth.

A day mail between London and Cambridge was established on 23 December 1842.

In 1844 royal assent was given to an Act to enable the Eastern Counties Railway Company to make a railway from the Northern and Eastern Railway at Newport by Cambridge to Ely, and from thence eastward to Brandon and westward to Peterborough. The clauses relating to Cambridge, in the light of modern conditions, make entertaining reading:

Assessing Act for Eastern Counties Railway Co.

And be it enacted, That the Vice Chancellor, the Proctors, and Pro-Proctors for the Time being of the University of Cambridge, with or without their Servants, and the Heads and Tutors of Colleges and Halls, and the Marshal and the Yeoman Bedel of the said University, or other Person or Persons, provided such other Person or Persons shall have been deputed by Writing under the Hand of the Vice Chancellor of the said University for the Time being, or of the Head or Governor, or in his Absence the Viceregent of any College or Hall in the said University, shall, at or about the Times of Trains of Carriages upon the said Railway starting or arriving, and at all reasonable Times have free Access to every Depôt or Station

for the Reception of Passengers proceeding by the Trains upon the said Railway, and to every Part thereof, and to every Booking Office, Ticket Office, or other Office or Place for Passengers upon the said Railway wheresoever such Office or Place shall be, and shall then and there be entitled to demand and take and have, without any unreasonable delay, from the proper Officer or Servant of the Company, such Information as it may be in the Power of any Officer or Servant of the Company to give, with reference to any Passenger or Person having passed or applying to pass on the said Railway, or otherwise coming to or being in or upon the said Depot or Station or Place, who shall be a Member of the said University or suspected of being such; and in case the said Company, or their Officers or Servants, or any of them, shall not permit such free Access to the said Depots or Stations as aforesaid, or shall not furnish such Information as herein-before mentioned, the said Officer or Servant of the said Company shall for each Default forfeit a Sum not exceeding Five Pounds.

And be it enacted, That if the said Vice Chancellor, or Proctors, or Pro-Proctors for the time being, of the said University, or Heads or Tutors of Colleges and Halls of the said University, or any of them, or any other Person or Persons deputed as aforesaid, shall at any Time or Times previous to the starting of any Train of Carriages upon the said Railway, notify to the proper Officer, Book-keeper, or Servant of the said Company, that any Person or Persons about to travel in or upon the said Railway is a Member of the University not having taken the Degree of Master of Arts or Bachelor in Civil Law or Medicine, and shall identify such Member to such proper Officer, Book-keeper, or Servant of the Company at the Time of giving such Notice, and require such Officer, Book-keeper, or Servant, to decline to take such Member of the University as a Passenger upon the said Railway, the proper Officer, Book-keeper, or Servant of the said Company shall immediately thereupon, and for the space of Twenty-four Hours after such Notice, Identification, and Requirement, refuse to convey such Member of the said University in or upon the said Railway, and which he is hereby authorized to do, notwithstanding such Member may have paid his Fare; and in case such Member of the said University shall be knowingly and wilfully allowed to be conveyed thereon after such Notice,

within the Time aforesaid, the Company shall for each Passenger so conveyed forfeit a sum not exceeding Five Pounds: Provided always, That no Member of the University represented as such to the said Company, or any of their Officers or Servants, by the said Vice Chancellor, Proctors, Pro-Proctors, Heads or Tutors of Colleges and Halls, or other Person or Persons deputed as aforesaid, or any of them, who shall be refused to be carried by the said Company, or by any of their Officers or Servants, shall on that account be entitled to claim or recover any Damage or Compensation from the said Company, or such Officers, Book-keepers or Servants, provided that in case such member shall have paid his Fare the same shall have been tendered or returned to him.

And be it enacted, That it shall not be lawful for the said Company to take up or set down any Person or Persons who shall be known to the Company or their Officers as Members of the University, but not having taken the Degree of Master of Arts or Bachelor in Civil Law or Medicine, on any Part of the said Railway, except at the regular appointed Stations of the Line; and in case the said Company shall take up or set down any such Person or Persons, except at such regular appointed Stations of the Line, they shall forfeit a Sum not exceeding Five Pounds for each Person so taken up or set down.

And be it enacted, That it shall not be lawful for the said Company to take up or set down any Passenger or Passengers at the Cambridge Railway Station, or at any Place within Three Miles of the same, between the Hours of Ten in the Morning and Five in the Afternoon on any Sunday, unless it should happen that any Train usually arriving at or departing from the said Station at or before the said Hour of Ten in the Morning has been delayed by some unavoidable Accident; and that for every person so taken up or set down the said Company shall forfeit a Sum not exceeding the sum of Five Pounds, to be recoverable and levied by summary Conviction and Distress and Sale before any Justice of the Peace for the County of Cambridge not holding any Office in the said University, and that such Justice of the Peace shall have Jurisdiction whether the said Person or Persons or any of them shall have been taken up or set down within the Borough of Cambridge, or the Precincts of the said University, or at any Place within the said

County, the said Forfeiture or Penalty to be paid and applied to and for the benefit and use of Addenbrooke's Hospital, or other County Charity that may in lieu thereof be hereafter from time to time declared for the Purpose under the Seal of the said University; and that the said Conviction may be in the form specified in the Schedule (D.) to this Act annexed; and that Service of any Information, Summons, or other legal Document upon any Clerk, Officer, or other Agent of the said Company, at any Station of the said Company within the said County or Borough of Cambridge, shall be sufficient service on the said Company.

And be it enacted, That nothing herein contained shall in any manner alienate, prejudice, alter, interfere with, or impede the Exercise, of any of the Rights, Privileges, or Authorities whatsoever, of the said University, or of any of the Officers, Ministers, or Servants thereto belonging.

On 29 July 1845 the Eastern Counties Railway from Bishop's Stortford by Newport, Cambridge, and Ely to Brandon was opened simultaneously with the Norfolk Railway from Brandon to Norwich. The Railway Directors entertained nearly 500 gentlemen at dinner at Cambridge. On August 8 they obtained an enabling Act for a line from Cambridge to Huntingdon.

Many railway schemes were considered in November 1845, especially that to obtain a Central Railway Station in Cambridge, but ultimately no site could be found nearer than that of the Eastern Counties near the Hill's Road. A Bill for making a railway from Cambridge to Oxford was introduced into Parliament. In the Lords only the part between Royston and Hitchin was sanctioned, and this part received royal assent on 16 July 1846.

In 1848 an Act was passed to extend the Royston and Hitchin Railway from Royston to the Cambridge and Bedford Railway at Shepreth.

An Act for making a railway from Chesterford to Newmarket, with a branch to Cambridge, received royal assent on 16 July 1846. On 1 October following day-mails were established from Cambridge to Bishop's Stortford, Ely, Thetford, Norwich .and Great Yarmouth.

In 1847, five years after her first journey by rail from

Windsor to London 'in half an hour, free from dust and crowd and heat, and I am quite charmed with it', Queen Victoria and the Prince Consort came to Cambridge by a special train. They left Tottenham at 11.28 and arrived at Cambridge at 12.53. In the same year the railway from Cambridge to St. Ives was opened for traffic. St. Ives to March was not opened until March 1848.

Drainage of the Fens

The earliest considerable work of engineering in the Fens, of which we have certain information, was made by the order of William the Conqueror in 1067 to reduce the Isle of Ely, where Hereward was in command of the English. It was a bridge or causeway begun at Aldreth, where the fen was four furlongs in breadth. The foundation was made of wood, stone, and faggots of all kinds, with trees and great pieces of timber fastened underneath with cowhides; but this structure proved so insecure that the greater part of his army, in attempting to pass over it, were drowned in the marshes.

The little new River near the foot of the Gogmagog Hills (now called the Nine-wells) was brought to the town of Cambridge by Trumpington Ford to wash the great King's Ditch in accordance with the recommendation of Archbishop Matthew Parker when Master of Corpus, published in his Chorographical Tables of Cambridge in 1574.

The authorities in Cambridge have always been alive to the great value of their communications by water, and especially of those with the port of Lynn. So that when extensive works for the drainage of the fens were being undertaken in the seventeenth century, they had reason to become apprehensive of the effect such drainage might have on the depth of the water in the navigation channels.

In 1636 a party of Aldermen and Heads of Colleges were appointed to view the works then being undertaken by the Commission of Sewers. The result was that eventually in 1646–7 a formal Petition was drawn up against the drainage of the Fens. It was argued that by such draining the navigation between Lynn and Cambridge would be

hindered, and thus the University would be deprived of the best part of the fuel and sundry other benefits which it then enjoyed, 'Since it appears by experience through the decay of the river of Grant, that if the work of draining had gone forward the said University could not in all probability have continued, or, if continued must have deeply suffered.'

Town and gown both felt very strongly about the matter, and on 24 March 1650–1 joined in a petition against the work of draining the Great Level of the Fens on the score of obstruction to navigation of the Grant and Ouse, 'by which conveyance from Lynn to Cambridge will be wholly taken away or obstructed—and also a great prejudice will befall a great part of this whole Nation by the stoppage of the general commerce at Sturbridge Fair.'

On the part of the City it was ordered on 4 April 1679 that the Mayors of Lynn and Cambridge should confer about the construction of locks in the rivers to maintain better navigation through the Great Level of the Fens, and on May 6 it was agreed that the Corporation should join with the University in promoting an Act of Parliament for the setting down of Locks, Sasses or Sluices in the River.

This was followed in 1696–7 by a Petition against the sluice and dam of the Bedford Level, and in 1701–2 by a Petition to Parliament as to navigation.

'Setting forth, That the Rivers running from Cambridge to King's Lynn heretofore were great and navigable Streams for Barges and Vessels; whereby the said University, and Parts adjacent, were well served with Coals, Fish, Salt, and other Commodities, at reasonable Rates; but for want of sufficient Banks, Stanks, and Sluices, for keeping up the Water in the shallow Places, the said River, in divers Places between Cambridge, and a Place about Seven Miles below, called Clayhive, is so silted, and grown up, that the said Navigation will be wholly lost, if not timely prevented: And praying, That leave may be given to bring in a Bill for cleansing and digging the Shallows of the Rivers running from the University and Town of Cambridge to King's Lynn; and for making and erecting Sluices, and other Engines, on the said River; whereby the

Navigation and Commerce of the said Town may be recovered and preserved.' (Cooper, iv. 48.)

Severe floods recurred occasionally, and not to everyone's detriment, for it's an ill flood that brings no one any good. For instance, in 1762 'On the withdrawing the Waters from the late Floods, such large quantities of Coals were left on Jesus Green, etc. that we have heard of some persons who have collected upwards of a Chaldron each, and many others have got from 5 to 10 or 12 Bushels.'

On 4 February 1777 the Seal of Corporation was set to a new Petition to Parliament.

In 1782 the Committee of the Thames and Canal Navigation of London caused a survey to be made by Mr. Whitworth with a view to judge of the practicability of a junction of the navigation of the Cam at Cambridge and the Stort at Bishop's Stortford by way of Saffron Walden. A meeting was convened to consider the matter, but nothing was done.

A Flood higher by a foot than that of October 10, 1762, took place in February of 1795. The water ran over the high walks at King's College, Clare Hall, Trinity College and St. John's, and the walk at the back of the colleges was for some hours impassable. A person plied with a cart opposite Magdalene College to carry passengers to the Great Bridge. The doors of the house of Mr. Anderson at Newnham, situated where the plantation belonging to Mr. Fawcett now is, were forced open by the violence of the waters, which stood 7 feet deep in the house.

'The family had barely time to escape up stairs, and during the whole night apprehensions were entertained that the house would give way. The inhabitants had no communication with any one until the following morning when Mr. Beales sent a barge with some provisions for them, as they were still confined upstairs. A good deal of the furniture floated away entirely, and some of it was found the following morning in Silver Street. There was a ball given by the Freemasons on that evening, and a carriage was waiting to take Mrs. Beales and her party to it. The coachman (in order to save his own life and that of his horses) was obliged to drive away, leaving the company behind. Monsieur Corneille, a celebrated hairdresser, whose

presence was anxiously awaited by several parties in the town, could not leave Mr. Beales's house, but was obliged to take up his residence there for the night. A member of Queens' College, who left the ball about four o'clock in the morning, utterly unconscious of what had taken place, sprang from the top of the steps on the left of the cloisters, and was surprised to find himself up to his waist in water.

Subsequently to the setting in of the frost, there had been a heavy fall of snow, and the frost broke up with a heavy rain. The bridge near Magdalene College, then called the Great Bridge, consisted of three small arches which effectually prevented the efflux of the water. The present bridge is so constructed that the flood, however large, passes under it without difficulty. Mr. Beales lost many chaldrons of coals, which were carried by the flood nearly a mile from his premises, and were stopt by the shallows on Midsummer Common, where for a long time a great number of boys supported themselves by dredging for them.'—Gunning's *Reminiscences*, ii. 1, 2, 3.

1813. February 18. A Commission of Sewers was granted, extending from where the river Grant first runs into the parish of Little Shelford, and from Arrington Bridge to the tails of the King's Mill in Cambridge, including the whole of that branch of the Cam over which Newnham Mill stands.

On July 24, 1851, 'The River Cam Navigation Act' received the royal assent. The parts of the river between King's Mill and Clayhithe were placed under the care of 11 Conservators, 5 representing the County, 3 the University, and 3 the Town Council.

'An Act for supplying the inhabitants of the University and Borough with Water' received Royal Assent on June 14, 1853. 'The Cambridge University and Town Waterworks Company' was incorporated with a capital of 2,500 £10 shares. Water rates were also fixed.

Societies

'The love of discussing on learned and philosophic topics was one of the characteristics of serious society in the Elizabethan age' (Sir J. E. Sandys). Even at that time it was not an unusual practise for people with similar

interests to meet together for friendly discussion. One such coterie met at the house on St. Peter's Hill in London of Dr. William Gilbert of St. John's College. Sir Humphrey Gilbert, half-brother to Sir Walter Raleigh, laid before Queen Elizabeth a scheme for the erection of 'An Achademy for educacion of her Maiesties Wardes and others, the youth of nobility and gentlemen,' where many well-paid teachers, including one in Natural Philosophy and one Doctor of Physic, were to hold forth. The duties of the physician were one day to 'reed physick and another surgery in the English tongue. He was never to alleage any medicine of any kind, but he was to declare the reason philosophical of every particular, and he was to show how the medicine was made and all the instruments used in making it. The physician was to practise surgery because there were very few good surgeons, for surgery was only to be learned in barber's shops, which was most dangerous. The physician was continually to practise with the Natural Philosopher to try and search out the riddles of Nature, they were to share a garden for the growing of simples, and for this they were to have an extra allowance.'

Towards the end of the seventeenth century Isaac Newton wrote that efforts to maintain a scientific society in Cambridge had failed, owing to the fact that no one there seemed to be willing to try experiments! It was doubtless to have been run on the lines of the Philosophical Society of Oxford and to have maintained a correspondence with the Royal Society. It was to be styled **The Philosophical Society of Cambridge.**

Newton wrote to Mr. Aston on 23 February 1684–5 from Cambridge:

The designe of a Philosophical Meeting here, Mr. Paget, when last with us, pusht forward, and I concurred with him, and engaged Dr. More to be of it; and others were spoke to partly by me, partly by Mr. Charles Montague (aft. Earl of Halifax); but that which chiefly dasht the business, was the want of persons willing to try experiments, he whom we chiefly relyed on refusing to concern himself in that kind. And more what to add further about this business I know not; but only this, that I should be very ready to concur with any persons for promoting such a designe, so far as I can do it

without engaging the loss of my own time in those things (Weld, *Hist. of Royal Soc.*, i. 305).

In 1754 Stephen Hales of Corpus was one of those who helped to found the **Royal Society of Arts**, at Rawthmell's Coffee House in Henrietta St., Covent Garden. The committee consisted of Viscount Folkstone, Lord Romney, Henry Baker, F.R.S., Gustavus Brander, F.R.S. and a director of the Bank of England, James Short the optician, John Goodchild of Teddington, Nicholas Crisp watchmaker, and the Rev. Stephen Hales. It was resolved unanimously to bestow premiums on boys and girls who shall produce the best piece of drawing, deeming the Art of Drawing to be 'absolutely necessary to many employments, trades and manufactures'. In Cambridge a second effort was made in 1784, when **The Society for the Promotion of Philosophy and General Literature** was established on 18 February. The original members were:

Isaac Milner M.A. Jacksonian Professor, afterwards President of Queens' College, William Coxe M.A. of King's College, Joseph Jowett LL.D. Regius Professor of Civil Law, Joseph Dacre Carlyle M.A. of Queens' College afterwards Professor of Arabic, Mr. Atkinson, Mr. Coulthurst, and William Farish M.A. of Magdalene College afterwards successively Professor of Chemistry and Jacksonian Professor. To these were afterwards added William Pearce B.D. of St. John's College Public Orator afterwards Dean of Ely and Master of Jesus College, Samuel Vince M.A. of Sidney College afterwards Plumian Professor, Busick Harwood M.B. Professor of Anatomy, Richard Relhan M.A. of Trinity College, Thomas Jones M.A. of Trinity College, Richard Porson of Trinity College afterwards Greek Professor, J. F. F. Emperius M.A. of Queens' College, Thomas Martyn B.D. Professor of Botany, Miles Popple M.A. of Trinity College, Mr. Brundish, Smithson Tennant M.B. of Emmanuel College afterwards Professor of Chemistry, Francis John Hyde Wollaston afterwards Jacksonian Professor, and Mr. Ainslie. (Cooper, iv. 410.)

But this second effort met with hardly more support than the first. For want of adequate support the Society was dissolved within two years after its formation [Milner, *Life of Dean Milner*, 19].

WHEWELL and his friends John Herschel, Charles Babbage, and Richard Jones used to meet at 'Sunday morning philosophical breakfasts' in 1815.

Greater success attended the next venture when the Cambridge Philosophical Society was established at a meeting on 2 November 1819. Dr. J. HAVILAND, Regius Professor of Physic, was in the chair, and WILLIAM FARISH, Jacksonian Professor, was elected the first president. On 6 August 1832 the **Cambridge Philosophical Society** was incorporated by Letters Patent with power to hold in mortmain to extent of £2,000 a year. The Society's Seal was engraved by Mr. Wyon with a figure of Sir I. Newton, after the statue in Trinity College chapel, and the inscription SOCIETAS PHILOSOPHICA CANTAB. Incorp. MDCCCXXXII.

The publications of the Society, the *Transactions* from 1820 and the *Proceedings* from 1843, have a world-wide circulation, and have played a most important part in preventing the scientific contributions of members of the University from being 'frittered and squandered away'.

The British Association held its 3rd meeting in Cambridge, 24–28 June 1833. Professor Adam Sedgwick, M.A., was President.

The Cambridge and Cambridgeshire **Mechanics Institute** was established at a public meeting at the Town Hall on the 12 March 1835.

On 11 March 1837 a society styled the **Ray Club** was founded for the cultivation of Natural Science by friendly intercourse and mutual instruction, in commemoration of the great Cambridge Naturalist. The Club consists of 12 resident Members of the University and 6 Associates who must be Undergraduates or B.A.s, and still holds an anniversary gathering on 29 November, the supposed day of Mr. Ray's birth. Its history and objects are described in *The Cambridge Ray Club* (with prefatory memoir by C. C. Babington Esq., M.A., the Secretary), Camb. 8vo. 1857.

Before we leave the subject of Societies, we should remember that it was CHARLES BABBAGE of Trinity who in 1820 was the leader in the foundation of the **Astronomical Society**—shortly to be followed by the **British Association** in 1832. In 1845 the Astronomical Society

swallowed up the old Mathematical Society of London 1717–1845, and de Morgan founded a new **London Mathematical Society** in 1866.

The numerous scientific Societies that were founded during the first decades of the nineteenth century undoubtedly reacted beneficially upon the Universities. As a foreign visitor to Cambridge, Dr. Carus, remarked in 1844, there was much that indicated the commencement 'of a new and fresh impulse in this otherwise antiquated University. . . . Of means of study there is no deficiency; the quiet of the place, the non-permission of theatres, and the non-existence of manufactories and trade are all favourable to the undisturbed pursuit of knowledge'.[1]

Museums

In the accounts of Dr. Spencer, Vice-Chancellor for 1673/4, there is an item 'Drawing several Maps & Schemes in order to the intended Museum £4' (MS. Baker xl. 67. Cooper). And on the 24 January following Dr. Benj. Laney, Bishop of Ely, by his will left the University £500 towards building a public school or Museum, on the condition that the foundation was laid within one year of his decease.

The more intelligent travellers during the second half of the seventeenth century and the early part of the eighteenth took great interest in natural rarities and curiosities and duly noted them in their diaries. For instance Ralph Thoresby, when at Cambridge on 16 May 1695, saw St. John's College and in the Library viewed a 'variety of natural marbles so delicately placed and inlaid as make curious prospects; we saw there also a little chameleon etc.', 'a Turkish Herbal', also the Egyptian bark with the Coptic characters (Thoresby's *Diary*, i. 293). And there were also considerable collections in other Colleges. The Woodwardian Collection was acquired in 1728.

But schemes for a public museum did not meet with much favour. However, on 13 December 1792 a grace was proposed for erecting opposite the Senate House a building comprising a Museum, lecture room, and Music Room from designs by John Soane Esq. It was rejected by a majority of 2 votes in the Non-Regent House.

[1] See footnote on p. 309.

Richard Viscount Fitzwilliam died on 5 February 1816, having by Will bequeathed to the University £100,000 in New South Sea Annuities for a Museum.

On 6 July 1819 the Duke of Gloucester, Chancellor of the University, accompanied by his Duchess and the Princess Sophia Matilda of Gloucester, visited the Fitzwilliam Museum and the Botanic Garden.

The Foundation Stone of the **Fitzwilliam Museum** was laid in 1837. The design was by George Basevi, and after his death in 1845, C. R. Cockerell, R.A., continued the work for two more years. It was finally completed about 1875 by E. M. Barry at a cost of £115,000.

In the extension of the museum that was opened on June 9, 1936 the very great beauty of the instruments of early science was acknowledged by the dedication of a special wall-case to the exhibition of such objects.

No. 15. Tudor 4-Pound and 2-Pound Weights. Used for making the new Standard Pound in 1840.
Archaeological Museum.

II

MENSURATION

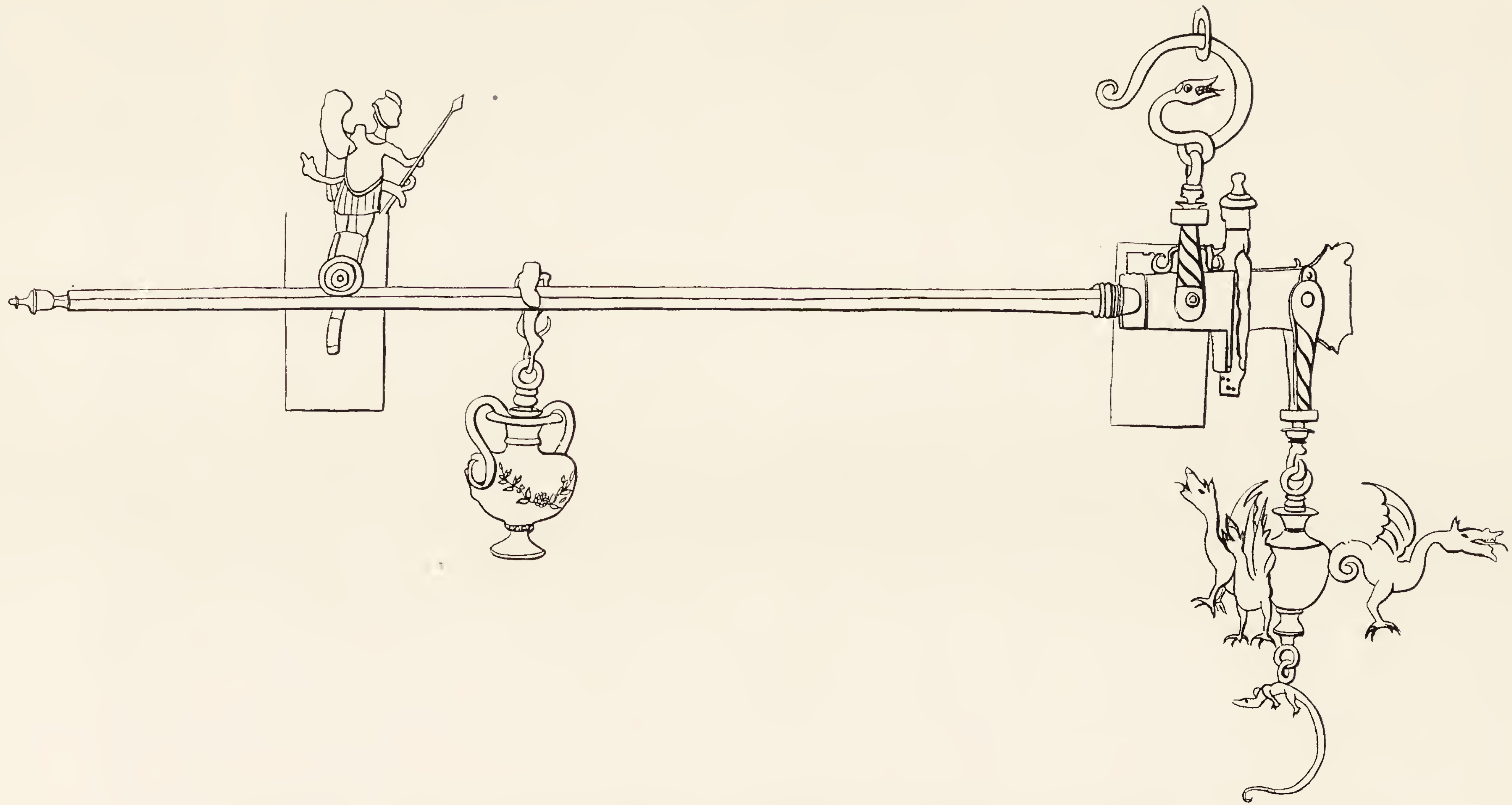
STANDARD WEIGHTS AND MEASURES

The earliest evidence of the use of a precision balance at Cambridge is supplied by the series of Saxon coins which are marked CRANT, which suggests that there was a mint at or near Grantchester, or by the Granta. They are dated from A.D. 975 to A.D. 1042. Later coins were struck there in the reign of William Rufus in the year 1090.

From 17 February, 1381/2 the Chancellor of the University had the power under charter to inspect the weights and measures used at Steresbrigge Fair, and on December 8, 1384, was given the right to seal bushels, half-bushels, and pecks, and for centuries the University exercised and redefined this ancient right.

This Fair of Sturbridge was of great antiquity, for there Irish clothmongers sold their goods in the reign of King Athelstan. King John granted the profits of the fair to the brethren of the Hospital of St. Mary Magdalen, and in 1539 Henry VIII transferred rights to the Corporation of Cambridge; his charter being confirmed by Elizabeth in 1588, in which year a new set of Standard measures was provided. It was the custom for the Mayor to mark out the ground on September 4, and for Delegates from the University to attend on September 18 to declare the fair open—for 3 weeks. In 1753 it was said that £100,000-worth of woollen goods might be sold in a week.

The Mayor of Cambridge held a court of Piepowder during the fair, and the University had the regulation of weights and measures. At the opening of the fair it was



The Steelyard of Sir Thomas Gresham. *With later additions. In the London Museum.*

therefore quite in order for the University to issue such a proclamation as was done in 1548:

'Yt every barrell of good Ale hold and conteyne xiiij gallons, xiij gallons of cleere ale and one gallon for the rest.' That there should be no other measures used than the gallon, pottle, quart, pint, and half-pint. All to be 'well and lawfully sealed and assyzed according to the Standard of the University'.

In 1597 a dispute arose between the County and the Town of Lynn with reference to the measures used for buying and selling corn 'by a busshell stryked with a rowle'. The Lynn folk replied that 'the Busshell and rowle have been used in Lynne as nowe it is, tyme without memory. . . . The measure for salte is, as it always was, but not x gallons according to the rate of the Whinchestter measure.'

The Steelyards which were used during the Tudor period for accurate weighing were often of very beautiful design, witness the superb specimen that belonged to Sir Thomas Gresham, the great London merchant, who seems to have resided at Gonville Hall long enough to have acquired the title *doctissimus*.

The practice in Cambridge was for the Proctors to 'examine the lawfulness of all waightes and measures, by the which anything is sould or uttered within the Faire'. And there was also a Gager 'to try and gage the lawfulness of the Assise of any Vessel, by and in which any victual or merchandise is uttered'. (1600–1.) Several of the Standards described below are dated 1610.

In 1646, April 16, a new brazen standard for gauging and trying barrels, kilderkins, and other vessels for ale or beer was ordered by the Corporation.

The prerogative of the two Universities to control weights and measures was always safeguarded in any new legislation, as for instance in the Act for ascertaining the Measures for retailing Ale and Beer to which royal assent was given on 11 April 1700.

By this every Mayor should 'cause and procure all ale quarts and ale pints to be compared, sized and equalled with the standard and then signed, stampt and markt.' Again, on April 5, 1710 an Act to regulate the price and

Assize of Bread received the royal assent,[1] and on 24 March 1763 there was a further Act relating to the Assize of Bread.

The Act of Weights and Measures of 9 Sept., 1835, contains the proviso that the overlooking of Weights and Measures shall be with the Chancellor and Vice-Chancellor, who shall appoint Inspectors. And under this Act, and until 1852, the University had the sole supervision of weights and measures within the town. It was pointed out that according to the practice then current no inspector is appointed by the Vice-Chancellor, but the Taxors (usually Clergymen) performed the duty. They occasionally seized defective weights and measures, but never prosecuted or published the names of the offenders.

It is interesting to note that after the destruction of the standards of length and weight in the fire at the Houses of Parliament, it was a Cambridge professor of Mineralogy, W. H. Miller, who was selected to help in the reconstruction of the new standards in 1839.

The Royal Commission considered that the inspection of weights and measures would be better exercised by the Police. And in 1934 the Home Secretary was petitioned to abolish Sturbridge Fair, held annually at Michaelmas, and in the Middle Ages one of the most famous fairs in the world, on the ground that it no longer served its purpose, being an ancient survival without any practical value. It was felt that owing to the utter neglect of the fair by the general public it was a waste of public money and time for the Mayor of Cambridge, the Town Clerk, the Town Crier, and the Bailiffs to go each year and proclaim the fair to an empty common.

Visitors to Cambridge are still amused at the old custom by which butter is sold by the yard. It is made up in pounds consisting of slender rolls a yard long, for the convenience of the college butlers who divide them into small lengths called 'sizes'.

[1] Harleian MSS. 7176, 7177.

MEASURES OF LENGTH

1. **Imperial Standard Yard** at 62° Fahrenheit. 1824.
No. 300. Weights and Measures Office.
By *Bate, London* for UNIVERSITY OF CAMBRIDGE 1824.

2. **Yard.**
Dept. of Mineralogy.
By *Robinson.*

2 a. **Standard Yard and Metre.** c. 1865.
Chemical Laboratory.
Yard of 5 George IV, ch. 74, and Metre of 27–8 Victoria, ch. 117. On porcelain, by I. Casella. No. 17. Published by the Metric Committee of the British Association.

STANDARD MEASURES OF CAPACITY

3. **Winchester Bushel.** Bronze. 1601.
Diameter 20 inches. Town Clerk's Office.
Inscribed:
ELIZABETH (**Rose**) DEI GRACIA ANGLIAE (**Portcullis**) FRANCIAE ET (**Fleur-de-lis**) HIBERNIAE REGINA E R 1601.

4. **7 pints Bronze Measure.** 1601.
Archaeological Museum.
Inscribed:

Crown
ER
ELIZABETH REGINA 1601.

Depth $9\frac{3}{4}$ inches; diam. at top $6\frac{5}{8}$ inches; diam. at bottom 5 inches.

5. **Pottle Measure.** $7\frac{3}{4}$ in. high × 5 in. 1641.
Arch. Mus.

C Royal R
16 Arms 41

·: A WINE POTLLE TRYED BY IOHN RENALDS AT THE TOWER :·

Height $7\frac{3}{4}$ inches; diameter 5 inches. A pottle was nominally 2 quarts, but the capacity of this one is only 3 pints.

CAMBRIDGE STANDARD MEASURES

A. No. 1   B. No. 9   C. No. 8   D. No. 3   E. No. 6   F. No. 35

NOS. 10–12. Steelyard Globe Weights

No. 18. Elizabethan Weights No. 13. Wool Weights
No. 14. Henry VIII Weights

CAMBRIDGE WEIGHTS

6. Half Gallon. **1646.**

Town Clerk's Office.

STANDARD OF THE TOWN OF CAMBRIDGE 1646.

7. Quart Dry Measure. Temp. **Charles II.**

Arch. Mus.

Inscribed: Crown
CAMBRIDGE. Stamp: C
⚜

Short by 2 oz. Turned wood, $6\frac{1}{2} \times 3\frac{1}{2}$ inches, with metal bands and wood handle.

8. Winchester Bushel 1823. **1823.**

University of Cambridge.

Also ½ **bushel, 1 peck,** ½ **peck,** ¼ **peck, 1 quart.**

9. Imperial Standard Half Gallon. **1824.**

Weights and Measures Office.

UNIVERSITY OF CAMBRIDGE

By 'Bate, London, Maker of the Exchequer Standards'. Indenture no. '300'.

WEIGHTS

10–12. Steel-yard Globe Weights.

Arch. Mus.

(*a*) From Clare, Suffolk. **13th Cent.**
(*b*) From Crawleys, Trumpington. **c. 1300.**
(*c*) With shields bearing '3 lions guardant passant', 'lion rampant', 'two-headed eagle'. **c. 1500.**

13. Wool Weights. **c. 1520 to 1780.**

Arch. Mus.

Eight in number including those of reigns of Henry VIII, Charles I, Anne, and George III.

14. 5 Standard Bell Weights. Temp. **Henry VIII.**

Arch. Mus.

With loop handles. Marked XXXXXXXXXXXII (= 112 lbs.), XXXXXVI, XXVIII, XIIII, VII, and with the Royal badge, a Tudor rose between supporters.

15. 4- and 2-pound Flat Weights. **Temp. Henry VIII.**

Marked with Tudor roses. These were used by Prof. Miller *On the Construction of the New Imperial Standard Pound and its copies in Platinum. Phil. Trans.* 1856.

16–17. Standard 28 and 7-pound Bell Weights.
Avoirdupois. **Temp. Elizabeth.**
Arch. Mus.

Mark: Crown
EL

[1588.

18. Set of 6 Standard Avoirdupois Bell Weights.
Arch. Mus.

LVI li, XXVIII li, XIIII li, VII li, IIII li, II li.

Inscribed AN° DO 15 Crown EL 88 A° REG XXX.

19. Nest of Eleven Standard Troy Cup Weights. 1588.
Arch. Mus. from the Registry.

CCLVI *TR*, CXXVIII, LXIIII, XXXII, XVI, VIII, IIII, II, I, [?½] Troy ounces.
Inscribed EL AN° DO 1588 A° REG XXX.

20. 8-pound Flat Weight. **Temp. William and Mary.**
Stamps: Crown & W, Dagger, Ā Arch. Mus.
∴ THO ∴ HANMER ∴ ESQUIRE ∴ THE ∴ LORD ∴ OF ∴ THE ∴ MANNER ∴ OF ∴ MILDENHALL ∴
Marks: Crown W † Ā

21. 2-ounce Flat Weight. **Temp. William and Mary.**
Arch. Mus.

Marks: Crown A ✝ A Ewer

22. Set of 7 Cup-Weights. 1773.
Arch. Mus.

24 [lbs.] Averdupoize, 14 [lbs.] Aver, 8 oz Avers, 4 Aver. 2. [1 missing] ½ oz. In 1758 such Cup-weights were made for the Commissioners by Harris.

23–24. Cup Weights. Two sets.

Mineralogical Museum.

25. Standard 7-pound Bell Weight. **1822.**

Weights and Measures Office.

UNIVERSITY OF CAMBRIDGE

	1822	
Stamps:	GR	[Portcullis]
	IIII	

26. Standard Cup Weights. **1822.**

W. & M. Office.

4 lb Avoir, 2 lb, 1 lb, 8 oz, 4 oz, 2 oz, 1 oz, 8 drms, 4 drms, 2 drms, [1 drm].

UNIVERSITY OF CAMBRIDGE 1822

27. 4-ounce Flat Weight. **1826.**

Arch. Mus.

Marks:	Ā	Shield of London	Crown G	Ewer

The Ewer was the mark of the Brass-founders Company.

28. Money-Changers' Weights. **c. 1400 to c. 1800.**

A long series in the Fitzwilliam Museum.

29. Money-Changers' Scales and Weights. **1657.**

Fitzwilliam Museum.

'Dese Gewichten maeckt *Martinus de Backer* inde Oude Brugh Steegh inde Goude Munt Balans tot Amsterdam.'

30. Money-Changers' Scales and Weights.

Archaeological Museum.

a. By 'Joh. Philipp Herbertz in Sohlingen, 1756'.

b. By 'Joh. Pet. Braselmann auf Wichlinghausen in Oberbarmen, 1778'.

31. Guinea Scales. c. 1800.

a. By H. Bell Prescot, Lancashire. Fitzwilliam Museum.

b. By Stephen Houghton & Son, Ormskirk. Arch. Mus.

32. Scales and Weights.

Arch. Museum.

By 'Young and Son, Scale-makers To Her Majesty, No. 5. Bear St., Leicester Square, London'.

33. Scales and Weights.

Cavendish Laboratory.

7-inch beam in mahogany box. [Figure]

By Rich^{d}. Vandome, No. 117 Leadenhall Street, London.

34. Scales and Weights.

Cavendish Laboratory.

6½-inch beam in oak box.

By Will^{m}. Sangster at King's Arms in Butcher Row, Temple Bar. [Figure]

35. Cavendish's Chemical Balance in Case. c. 1760.

Royal Institution.

Made by Harrison to the design of Cavendish, whose heir Lord George Cavendish gave it to Davy, who gave it to J. G. Children, who gave it to Alex. Green, who gave it to the R.I. in 1868.

36-37. Wollaston's Chemical Balances. c. 1810.

Cavendish Laboratory.

38-39. Balances used by Prof. W. H. Miller in making the Standard Pound. c. 1830-40.

Dept. of Mineralogy.

10½-inch beam by 'Robinson, 38 Devonshire St. Portman Place'.

5½-inch by ditto.

40. Chemical Balance.

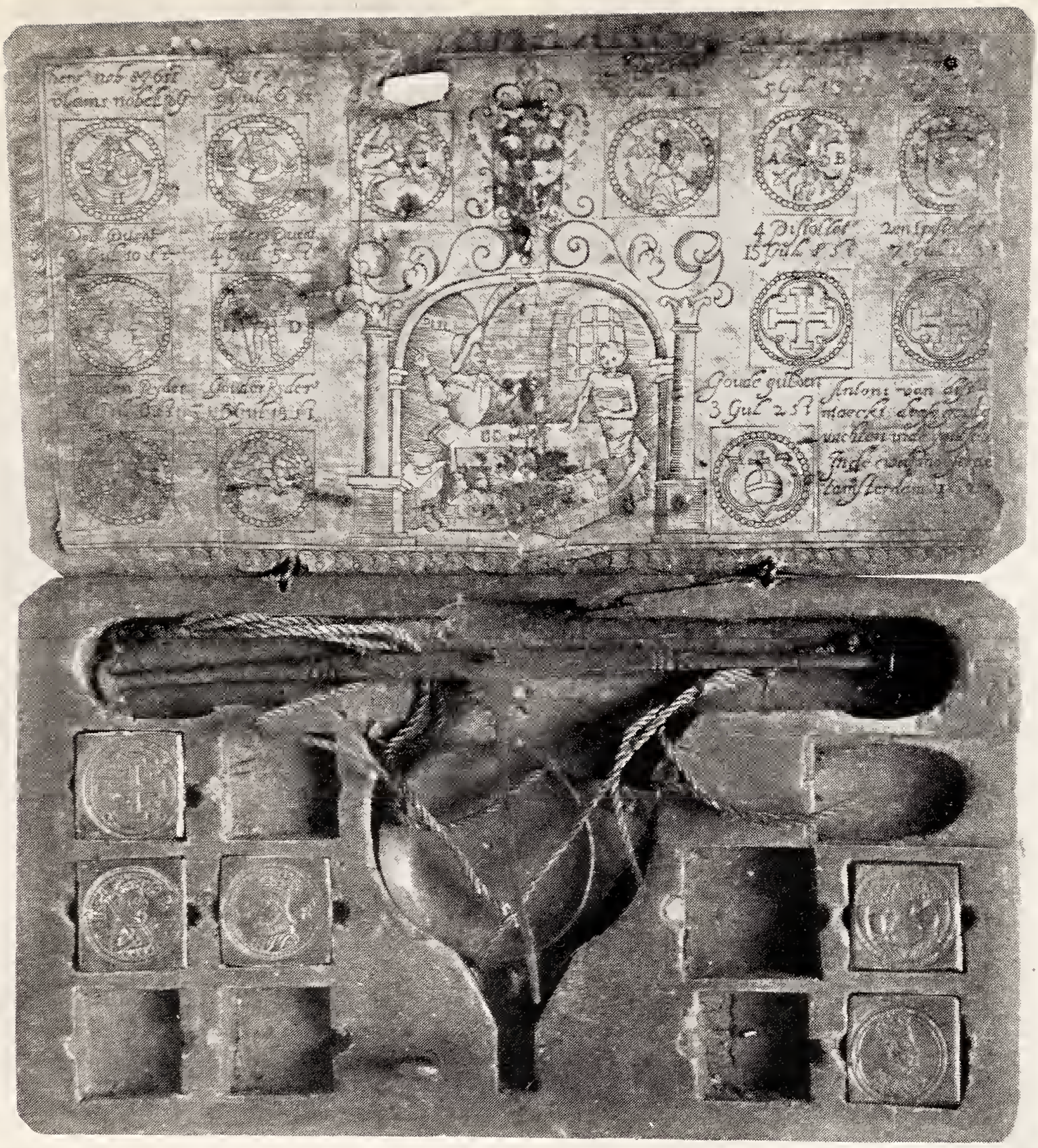
Dept. of Mineralogy.

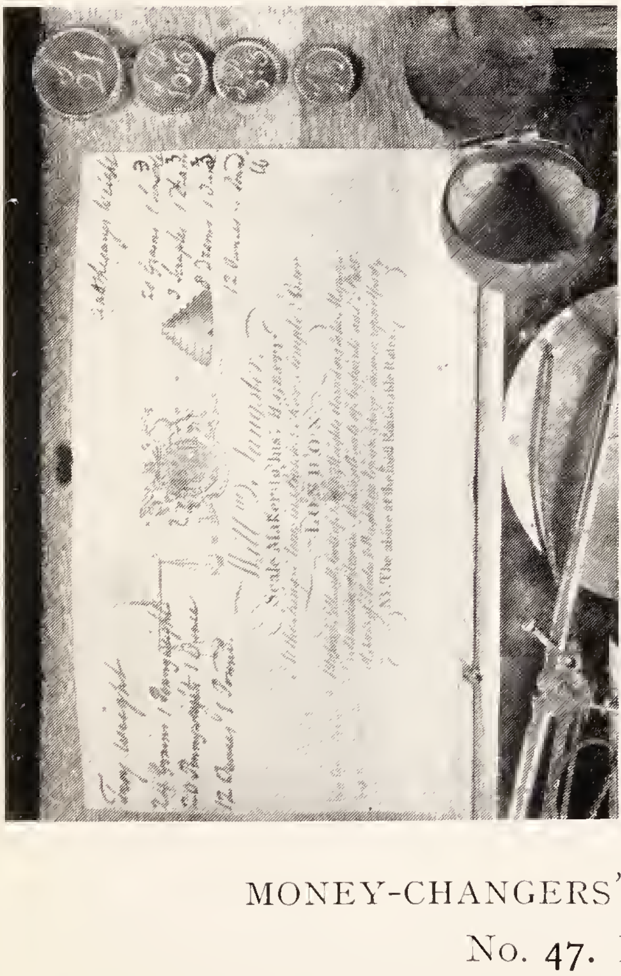
By 'Kiessler & Neu London'.

41. Chinese Ivory Dochin.

Professor Hutchinson.

Length 11 inches in wooden box.





MONEY-CHANGERS' SCALES AND WEIGHTS

No. 47. Dutch form

No. 49. By Sangster

No. 48. By Vandome

III

MATHEMATICS

SIXTEENTH-CENTURY MATHEMATICIANS

It is a significant fact that the first names on our list of mathematicians were those of migrants from Oxford to Cambridge.

CUTHBERT TUNSTAL was born at Hackforth, Yorks in 1474 or 1475, and went from Balliol (1491) to King's Hall in Cambridge on account of the plague. He produced the *De Arte Supputandi*, the first book on Arithmetic printed in England, in the year 1522, when he became Bishop of London. For this work special type for cancelled digits was used. A sumptuous copy, printed on vellum, was given by Tunstal to Corpus Christi College, Oxford. He died in 1559–60 and is buried at Lambeth. Few great men have lived a fuller life.

ROBERT RECORD, c. 1510–58, was also one of those who can claim the benefits of both Oxford and Cambridge; he migrated from All Souls and took the Cambridge medical degree in 1545. His grounding in Mathematics seems, however, to have come within his Oxford period. His works, the *Grounde of Artes* and the *Whetstone of Witte*, were standard text-books for many generations and popularized the use of signs $+$, $-$, $\times$, and $=$, the last of which was his invention. Later on he became Comptroller of Mints and Monies in Ireland, but apparently without great advantage either to the State or to himself, for he ended his career in prison, it is said, for debt.

WILLIAM GILBERT of Colchester acted as Mathematical examiner at St. John's in 1565 and 1566. See p. 111.

Henry Billingsley, scholar of St. John's 1551, *d.* 1606, is said to have been tutored by one Whytehead, an Augustinian friar, who was maintained by him. He published

The Elements of Geometrie of the most auncient Philosopher Evclide of Megara now first translated into the Englishe toung. . . . With a preface . . . by M. J. Dee, specifying the chiefe Mathematicale sciēces. 1570; repr. 1661.

Thomas Digges, c. 1545–95, son of Leonard Digges of Wotton, Kent, has been wrongly identified with a Thomas Dygges who matriculated at Queens' in 1546 but probably did not go up to Cambridge at all. For his proficiency in mathematical and military matters he was indebted to his father and to John Dee, his 'second parent in mathematics and astronomy'. In 1583 he was appointed superintendent of the works and fortifications at Dover. His published writings include the following:

Alae seu Scalae Mathematicae. 1573.
Pantometria. 1571.
Prognostication. 1578. } His father Leonard's works.
Stratioticos. 1579.
Plan of Dover Castle drawn in 1581 on a scale of 15 poles to an inch. MS. Addit. 11815.

He has been elevated to his true position as the first great English astronomer to advocate the Copernican theory, with its moving Earth, and he may also claim the honour of having originated the idea of the Infinity of the Universe in 1576.

Thomas Hood, matric. as a pensioner of Trinity 1573; appointed first mathematical lecturer in Staples Chapel in Leadenhall St. c. 1582. Licensed to practise physic 1585. In 1588 the mathematical lectures were transferred to the house of Thomas Smith in Grass Street.

Vse of the Celestial Globe in plano, set foorth in two hemispheres. [They were sold at the author's house in Abchurch Lane.]
Vse of the Iacobs staffe. Lond. 1590.
Pet. Ramus his Geometrie, transl. by Th. Hood. 1590.
The Vse of both of the Globes, Coelestiall and Terrestriall, most plainely delivered in the forme of a Dialogue: containing

most pleasant and profitable conclusions for the Mariners. Lond. 1592.

The elements of arithmeticke. transl. from lat. of C. Vrstitius. 1596.

A Regiment of the Sea, containing very necessary matters for all sorts of Sea-men and Trauailers, as Masters of Ships, Pilots, Marriners and Marchants . . . written by William Bourne. Newly corrected & amended by Tho. Hood D. in Phisicke who hath added *a new Regiment & Table of Declination.* Whereunto is also adjoyned the *Mariners guide, with a perfect Sea Carde* by the said Tho. Hood. Lond. 1596.

The making and vse of the Geometricall Instrument, called a Sector. Whereby many necessarie Geometricall conclusions concerning the proportionall description, and division of lines, and figures, the drawing of a plot of ground, the translating of it from one quantitie to another, and casting of it vp Geometrically, the measuring of heights, lengths, and breadths may be mechanically performed with great expedition, ease, and delight to all those, which commonly follow the practise of the Mathematicall Arts, either in Surveying of Land or otherwise. Lond. 1598.

Letter to Lord Burghley respecting the mathematical lecture.

Richard Cavendish, C.C.C. 1569, M.A. 1572/3; *d.* c. 1600, was the author of a Translation of *Euclid* into English, and *The Image of Nature and Grace.* 1574.

He was uncle to Thomas Cavendish, the circumnavigator. Both visited Dr. Dee at Mortlake on 18 May 1590. Under date 31 July 1590, Dr. Dee wrote: 'I gave Mr. Richard Candish the copy of Paracelsus twelve lettres, written in French with my own hand; and he promised me, before my wife, never to disclose to any that he hath it; and that yf he dye before me he will restore it agayn to me; but if I dy befor him, that he shall deliver it to one of my sonnes, most fit among them to have it.'

Among the last of the mathematicians of the sixteenth century was Edward Wright, *b.* in Norfolk about 1560, who became a fellow of Caius College and died in 1615, having done more to put the practice of navigation on a scientific basis than any of his predecessors. About 1600

he was Lecturer on Mathematics to the East India Company. Among his pupils was Henry, Prince of Wales, son of James I. His work for navigation will be referred to on p. 209.

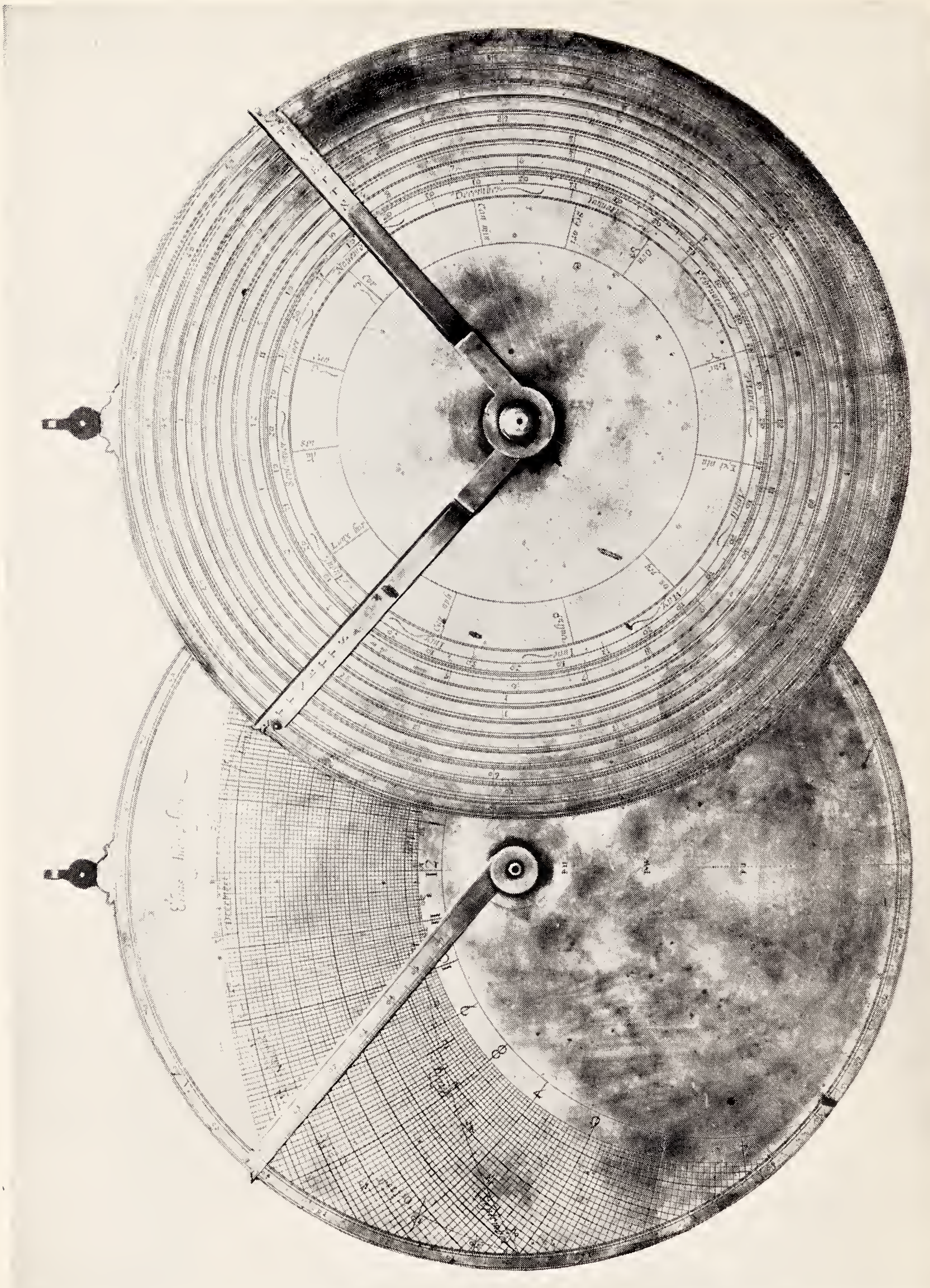
Henry Briggs (1561–1631) of St. John's College should always be remembered for his great and laborious calculation of tables of Logarithms, and, although this is less generally known, for having taught people to do long division by the usual modern method. He graduated in 1581 and became a fellow of St. John's in 1588. His exceptional talents were subsequently rewarded by his appointment to the first Gresham Professorship of Geometry in London 1596–1620, and to the first Savilian Professorship at Oxford 1619–31. It was due to Briggs's enthusiasm for Napier's great discovery that Kepler became convinced of the utility of the logarithmic method and used logarithms in his German tables of 1625 and 1629. He died at Merton College, Oxford, Jan. 26, 1630–1.

THE SEVENTEENTH CENTURY

Those who, like Wordsworth, have taken stock of the studies at our Universities, agree that during the first half of the seventeenth century Cambridge was not mathematical at all. Indeed, Wallis of Emmanuel says that mathematics were 'scarce looked upon as *Academical* studies, but rather *Mechanical*. . . . And among more than two hundred students in our College, I do not know of any two (perhaps not any) who had more of *Mathematicks* than I, (if so much) which was then but little; And but very few, in that whole University. For the Study of *Mathematicks* was at that time more cultivated in *London* than in the universities'. (Wordsworth, *Scholae.*)

Aristotle and the Schoolmen were still in the ascendant. But during this period advances that were being made in the physical sciences and in astronomy, and the spread of the Baconian philosophy, were slowly but surely preparing the way for Newton.

It should also be remembered that during this century mathematical learning lay much in the knowledge of instruments, or as Sir Henry Savile said, in the 'doing of tricks', so when learned men came to call on Descartes and



NO. 56. OUGHTRED'S CIRCLES OF PROPORTION
And No. 167. Double Horizontal Dial

desire him to show his box of instruments, 'he would drawe out a little drawer under his table, and show them a paire of compasses with one of the legges broken; and then, for his ruler, he used a sheet of paper folded double'. (Aubrey.)

In 1600–1 there was one Mathematical Reader at the University of Cambridge 'to reade of the art of Arithmeticke, of Geometry, of Cosmographie or of Astronomy in such sort as is fit for his Auditory, being also of Sophisters and Bacchelers of Arte'.

It is, therefore, scarcely surprising that in a Report made in July 1625 on the Cambridge system of education, it was found that 'The defects in studies comprise the mathematics, almost neglected in all Colleges, and in many, the tongues'. The remedy proposed was for every College to have a mathematic lecturer endowed with a reasonable salary.

The honour of having trained a man who should produce a book containing all that was then known of Arithmetic and Algebra falls to Eton and King's College.

In 1631 WILLIAM OUGHTRED (1575–1660) published a modest little duodecimo volume entitled: *Arithmeticae in Numeris et Speciebus Institutio; quae tum Logisticae, tum Analyticae, atque adeo totius Mathematicae, quasi Clavis est*, 12mo. 1631.

This is the first edition of his *Clavis Mathematicae.* In it he introduced the symbol × for multiplication, and the symbol : : for proportion e.g. *a . b : : c . d* which previously had been usually written *a-b-c-d*. (W. W. R. Ball.)

42. Oughtred's Circles of Proportion. **c. 1640.**

Diam. $12\frac{3}{8}$ in.

Cavendish Laboratory.

'*Elias Allen fecit.*'

A pair of Compass legs marked 'S, T, T, N, E, T, T, S' are pivoted to the centre of the disc engraved with circular logarithmic scales.

On the back is the Double Horizontal Dial mentioned on p. 183.

Also a Calendar Circle of days of months.

The fine circular slide-rule or 'Circles of Proportion' on exhibition with the Lewis Evans Collection at Oxford was undoubtedly made by Elias Allen to Oughtred's specification. It is dated 1634, and is the earliest known instance of the application of logarithmic scales to an instrument.

Close on half a century later he wrote a treatise on trigonometry (*Canones Sinuum*, 1657) in which abbreviations for *sine, cosine*, &c., were used. He also added a dot so as to make : the symbol for a ratio.

John Aubrey has much to say about him. He came up to King's College as a scholar from Eton in 1592, and at the age of 23 published *Horologiographia Geometrica*.

'He was a little man, had black haire and black eies, with a great deal of spirit. His witt was always working. He would drawe lines and diagrams on the dust.' Aubrey was told by his eldest son, Christopher, that 'his father did use to lye a bed till eleaven or twelve o'clock, with his doublet on, ever since he can remember. Studyed late at night; went not to bed before 11 o'clock; had his tinder box by him; and on the top of his bed-staffe, he had his ink-horne fixt. He slept but little. Sometimes he went not to bed in two or three nights, and would not come downe to meales till he had found out the *quaesitum*. He was more famous abroad for his learning, & more esteemed, than at home. Several great mathematicians came over into England on purpose to be acquainted with him. . . . Seth Ward came to him, and lived with him halfe a yeare, and learned all his mathematiques of him, and he would not take a farthing for his diet. Sir Jonas More [the surveyor of the Fens] was with him a good while, and learnt; he was but an ordinary logist before. Sir Charles Scarborough [Caius] was his scholar; so was Mr. [Francis] Smethwyck R.S.Soc. [1667]. One Mr. Austin (a most ingeniose man) was his scholar, and studyed so much that he became mad, fell a laughing, and so dyed to the great griefe of the old gentleman Mr. Stokes, another scholar, fell mad and dreamt that the good old gentleman came to him and gave him good advice, and so he recovered and is still well. Mr. Thomas Henshawe, R.S.S. was his scholar, when a young gentleman; but he did not so much like any as those that tugged and tooke paines to worke out

questions. He taught all free. He could not endure to see a scholar write an ill hand; he taught them all presently to mend their hands. Amongst others Mr. T. Henshaw, who when he came to him wrote a lamentable hand, he taught to write very well. He wrote a very elegant hand, and drew his schemes most neatly, as they had been cut in copper. . . .

'His wife was a penurious woman, and would not allow him to burne candle after supper, by which meanes many a good notion is lost, and many a problem unsolved; so that Mr. Henshawe, when he was there, bought candle, which was a great comfort to the old man.' Aubrey inherited one of his books, a Pitiscus, embellished with excellent marginal notes, and was sorry that he could not have also obtained his Billingsley's *Euclid*, which J. Collins says was full of his annotations. He died 13 June 1660, aged 88.

In those early days when the scope of mathematical science was being enormously extended following upon the invention of analytical geometry by the Jesuit Descartes in 1637, the means of communication of ideas between savants were far more difficult than is now the case. The world of science was therefore greatly beholden to men like John Pell of Trinity (1610–85), who, having for a time professed mathematics in Amsterdam, returned to London in 1661 and maintained a large correspondence with the principal mathematicians of the time. He published a *Table of* 10,000 *Square Numbers* in 1672. His edition of Branker's translation of Rahn's *Introduction to Algebra* 1668 contains the symbol ÷, then used for division for the first time.

John Wallis (1616–1703) must be mentioned among Cambridge men of science—for he studied medicine at Emmanuel College and took orders from Queens' College. Yet his more important mathematical work, having been done while Savilian Professor at Oxford, from 1649 to his death in 1703, is more appropriately considered elsewhere. (W. W. R. Ball, *History of Mathematics*.)

He 'fell not to the study of mathematiques till he was above twenty', but was a good student. Fame came to him early in life for being a witness at Laud's trial, for introducing popish innovations into the University of

Cambridge, and for deciphering the letters of Charles I taken at the battle of Naseby. Aubrey had a high opinion of his great gifts as a mathematician, but considered that his greed for fame led him to 'steal feathers from others to adorn his own cap, e.g. he lies in watch at Sir Christopher Wren's discourse, Mr. Rob. Hooke, Dr. William Holder etc, putts downe their notions in his note-booke, and then prints it, without owneing the authors'.

His most important works were *Arithmetica infinitorum* 1656; his *Rectification of algebraic curves* 1659; on *Statics* 1669; *Dynamics* 1670, and *Algebra* 1685.

Seth Ward came up to Sidney Sussex 1632 as servitor to Dr. Ward, the master, 'who being much taken with his ingenuity and industry, as also by his suavity of nature, quickly made him scholar of the house, and after fellowe [1640]. . . . His father taught him common arithmetique, and his genius lay much to the mathematiques, which being naturall to him, he quickly and easily attayned. Sir Charles Scarborough M.D. (then an ingeniose young student and fellow of Caius College) was his great acquaintance, both students in mathematiques, which the better to perfect, they went to Mr. William Oughtred, at Albury in Surrey, to be informed by him in his *Clavis Mathematica*, which was then a book of aenigmata. Mr. Oughtred treated them with exceeding humanity, being pleased at his heart, when an ingeniose young man came to him, that would ply his Algebra hard.

'When they returned to Cambridge, they read the *Clavis Mathematica* to their pupills, which was the first time that that booke was ever read in a university.'

About 1649 Seth Ward had to live at Wadham College with Dr. Wilkins, the warden, Ralph Bathurst, and others, and there began those Philosophicall Experiments which ultimately led to the foundation of the Royal Society. When he became Bishop of Salisbury he, remembering his early friends, gave 'a noble pendulum clock which goes for a weeke' to the Royal Society, and in 1679 he gave to Sidney College £1,000. Aubrey summed up a character-sketch of him by observing that in spite of his being so great a student of mathematics and knotty points, 'which does use to make men unfit for businesse, he is so cleare

and ready as no sollicitor is more adroit for looking after affaires'. (Aubrey, *Lives.*) He died 1688–9.

Another mathematician of high repute was Dr. WILLIAM HOLDER (1616–97), Fellow of Pembroke Hall 1640, who 'was very helpfull in the education of his brother-in-law Mr. Christopher Wren, a youth of a prodigious inventive witt, and of whom he was as tender as if he had been his own child, who gave him his first instructions in geometrie and arithmetique'.

The best mathematician in the world of 1645 to 1650, according to Sir Christopher Wren, was Dr. EDWARD DAVENANT of Queens'. He held such strong views as to reprinting matter that had already been published, that 'he would have a man knock't in the head that should write anything in mathematiques that had been written of before.' He gave John Aubrey his first lessons in Algebra; and both his daughters became Algebraists.

Cambridge owes its premier mathematical professorship to the patriotism of a member of St. John's College, a college which has produced so many illustrious students in that faculty. HENRY LUCAS, M.P. for the University, provided in his will for land to produce £100 a year to be purchased as an endowment. He died on July 22, 1663. The foundation deed of the Lucasian Professorship was dated December 19, 1663, and in 1664 the holder was granted a Dispensation to hold a Fellowship without taking Holy Orders. Barrow was elected.

ISAAC BARROW (1630–77), fellow of Trinity, had had a very chequered career. Having been driven out of Cambridge in 1655 by persecution of the Independents, he travelled in France, Italy, Turkey, Germany, and Holland. On his return in 1660 he was appointed to the Chair of Greek at Cambridge, then to that of Geometry at Gresham College.

He is described by Ball as 'low in stature, lean, and of a pale complexion', slovenly in his dress and an inveterate smoker. His ready and caustic wit made him a favourite of Charles II, and his integrity and stately eloquence made him greatly respected. He was appointed master of Trinity College in 1672.

His most important work for mathematics was done

during the five years of his tenure of the first Lucasian Professorship. 'The better to secure the End of so noble and useful a Foundation, he took Care that himself and his Successors should be obliged to leave, yearly, to the University ten written lectures.' His inaugural lecture was delivered on March 14, 1664, and others with those for 1665 and 1666 were published posthumously in 1683 as *Lectiones Mathematicae* XXIII. The *Lectiones Opticae et Geometricae* were, however, printed in his lifetime in 1669.

He found the correct expression for the tangents of a number of curves and suggested new ways for determining their areas. His optical lectures defined the geometrical focus of a point seen by reflexion or refraction, and showed how the image of an object is the aggregate of the geometrical foci of every point on the object.

In 1669 he determined to make theology his whole-time study and resign the Lucasian chair. Barrow proposed as his successor his pupil ISAAC NEWTON, then 27 years of age.

NEWTON (1642–1727) had had no training in mathematics before he came up to Trinity in 1661, but happening to be fascinated by the to him incomprehensible expressions in an astrological book which he had picked up at Stourbridge Fair, he bought a Euclid and read Oughtred's *Clavis* and Descartes's *Géométrie* with a view to elucidating the astrology. Kepler's *Optics* and Wallis's *Arithmetica Infinitorum* followed, and thus he laid the foundation to those flights of his unparalleled genius which gave Cambridge, then not the home of English mathematics, its mathematical renown.

Already while attending Barrow's lectures Newton was the author of a paper *On Analysis by Equations with an Infinite number of Terms*, a paper that was read by Collins with approval, but was not published, whereby Newton lost his claim to priority as the discoverer of the Method of Fluxions.

Wallis had discovered a general rule for determining areas which are defined by curves in which one coordinate is proportional to a power of the other coordinate; but only so long as this power is a positive whole number. If, however, the power is negative or fractional the method of Wallis is of no use.

This is where Newton, with the aid of the Binomial Theorem, went further. When he was rusticating at Boothby in Lincolnshire because of the plague, he found a method of calculating the area defined by the curve when the volume of a gas is plotted against the pressure. He was thus led on to the idea of regarding positions, lengths, areas, or volumes as fluent, as varying continuously according to a law, dependent on the flow of the two co-ordinates that define the curve.

The account which Newton himself has left us of the development of his theory of Universal Gravitation is of compelling interest, especially when we remember that it came to his mind as he has recorded, worked out in the two Plague years of 1665 and 1666, 'for in those days I was in the prime of my age [22 years] for invention, and minded mathematics and philosophy more than at any time since'.

> In the beginning of the year 1665 I found the method of approximating series and the rule for deducing any dignity of any binomial into such a series. The same year, in May, I found the method of tangents of Gregory and Slusius, and in November had the direct method of fluxions,[1] and the next year, in January, had the theory of colours, and in May following I had entrance into the inverse method of fluxions.[1] And the same year I began to think of gravity extending to the orb of the Moon, and having found out how to estimate the force with which a globe revolving within a sphere presses the surface of the sphere, from Kepler's rule of the periodical times of the planets being in a sesquialterate proportion of their distances from the centres of their orbs, I deduced that the forces which keep the planets in their orbs must be reciprocally as the squares of their distances from the centres about which they revolve; and thereby compared the force of gravity at the surface of the earth, and found them answer pretty nearly.

Universal Gravitation

It was in 1666 that Newton, down from Cambridge owing to the plague, was quietly staying at home at Wools-

[1] The 'method of fluxions' was the foundation of the differential calculus: the 'inverse method of fluxions' was that of the integral calculus.

thorpe when he hit on the idea that the gravitational pull which from time immemorial had been known to be exerted by the earth on apples and all other terrestrial bodies, may also account for the motion of the moon, and further involve a principle that has a universal application.

When he set to and worked out the problem on the basis of Kepler's Third Law (1619) that 'the square of the time taken by a planet to describe its path once round the sun is proportional to the cube of its mean distance from the sun', he found that the computed acceleration due to the earth's pull on the moon was nearly 16 per cent. too small. But though so near success he postponed any further attempt until 12 years later, after Robert Hooke and Picard had drawn his attention to the problem. The further story of the case has been narrated in a most interesting manner by Prof. Brodetsky, who tells how Hooke, and his friends for him, claimed priority in having postulated universal gravitation, but how he did not substantiate the claim by mathematical proof; how Newton, whose Woolsthorpe calculations were faulty owing to his ignorance of the length of the radius of the earth; how in 1672 Picard had communicated the correct figure to the Royal Society, but that Newton had paid no attention to it; how Hooke on becoming Secretary of the Royal Society wrote to Newton for some new communication to the society; how Newton replied by sending a dissertation on the rotation of the earth, but had arrived at a wrong conclusion as to the point of arrival of a falling body dropped from a height above the earth, and of how Hooke both corrected him and did that classic experiment in December 1679, which supplied 'the first ocular proof in history of the rotation of the earth'.

When it came to defining the path travelled by a body attracted by the earth, Newton conjectured it to be a *spiral* curve. Hooke dissented, stating that the path would be an *ellipse* with a focus at the centre of the earth. Hooke's opinion was more than a guess: it was based on that intuition which comes to the born and practised experimentalist, but he seems not to have had sufficient mathematics to prove his case. But when Hooke had 'corrected the spiral', and had suggested that the curve

was an ellipse, Newton found no difficulty in proving the proposition that when a moving body is being attracted to a fixed point with a force varying as the inverse square of the distance from this point, it describes an ellipse with a focus at the centre of attraction. Hooke even went further; he asserted that this inverse square law would explain all the celestial motions. In the meantime, in 1682 Newton became aware of the approximate value of the earth's radius published by Picard in 1872, and with considerable emotion, proceeding to correct his Woolsthorpe calculations, found that fact and theory of the moon's motion were now in agreement. But although he had practically proved 'the truth of the theory of universal gravitation, a theory of the profoundest interest to civilized mankind', he refrained from publication; indeed, he might have carried the secret to the grave with him had it not happened that Halley visited him and almost forcibly induced him to put pen to paper and send the result *De Motu* to the Royal Society. It was communicated on December 10, 1684.

In April 1685, at the age of 42, Newton began a comprehensive work on the entire physical and mathematical aspect of the case, his *De Motu Corporum*. Beginning with a clear enunciation of the principles of Dynamics, an introduction describing the theory of fluxions, but without the notation which had long before been suggested by Leibniz and was in use on the Continent, he formulates the three Laws of Motion deduced from the historic experiments on dynamics of Galileo, viz. I. That if there be no force a body moves uniformly in a straight line.

II. Change of direction or of acceleration is always due to the action of a force.

III. Action and Reaction between two bodies are equal and opposite.

The application of these laws to the fullest extent and simultaneously involving all the attractions between sun, planets, satellites, and stars, would present so immensely difficult a problem, that it is doubtful whether it would ever have been solved, any more than the youth could break the bundle of sticks, but, by dividing and simplifying the problems progress was possible. Thus, as a beginning,

he confined his attention to the problem of the mutual interaction of a pair of heavenly bodies, e.g. of the sun and one planet, or of a planet and one satellite. But it immediately occurred to him that such celestial bodies are of a considerable size, and are composite masses of parts, each of which must exercise some gravitational effect, so that it became necessary to ascertain what the total effect would be.

If the matter of a sphere be arranged symmetrically round the centre, it produces at any external point the same force as if the whole mass of the sphere were condensed into a tiny spot at the very centre of the sphere. The proof of this theorem was of incalculable value and remains as one of Newton's triumphs.

The second book of *De Motu* deals with motion in a resisting medium, the effect of which he supposed to be either proportional to the velocity, or to the square of the velocity or to both combined. The resisting media he had in his mind were air and water, and the cases which he examined are those of a pendulum swinging in, and being resisted by, the air; and the case of waves of water, which in turn illustrate the method by which sound is propagated through air.

Finally, he showed that the Cartesian theory of Vortices is not possible as an explanation of celestial motions, which according to it should go faster the further the moving body is from the sun.

Book III, *De Mundi Systemate*, is the crowning achievement of Newton's work. In it the solar system is explained by the Law of Universal Gravitation. Newton first tells us that 'Like effects in nature are produced by like causes'. The physical laws which hold good on the earth, must be equally true of the celestial bodies. Then in support of his Law of Inverse squares he quotes the case of the moons of Jupiter, which obey Kepler's third law, that the squares of the periods are proportional to the cubes of the mean distances.

Then he proceeds to his main thesis that the force between two bodies is proportional to the product of their masses, and is inversely proportional to the square of the distance between them. Next he determines the place of

the centre of gravity of our solar system as a whole—pointing out that this could not be in the centre of the sun as Copernicus thought, but on that side of the centre of the sun at which the planets would tend to produce the greatest gravitational pull.

After pointing out that the planets rotate with a uniform speed, he proves that such rotation must cause a flattening at the poles—such as Cassini and Flamsteed had told him they had observed in the case of Jupiter. In the case of the earth the amount of this flattening may be measured by pendulum experiments, and by it Newton was the first to explain the top-like rotation of the Earth's axis, which gives rise to the 'precession of the equinoxes', which had been recognized for centuries but had never been previously understood.

Lastly he gives a full and satisfactory explanation of Tides and the suggestion that some Comets travel along elliptical tracks—a suggestion that was welcomed by Halley, who upon this idea predicted the return of the comet of 1682 in 1758/9. Within a month of the time given by the calculations based upon Newton's laws, Halley's comet reappeared, as it has done in 1835 and 1910: surely the greatest indication of the value of the immortal achievement of Newton as stated in the *Principia* in 1687.

There are good grounds for believing that Newton was expounding his system of natural philosophy several years before the issue of the first edition of the *Principia* in 1687. Indeed, the perfection of that great work implies a long period of preparation and of that mastery of the subject which alone comes of teaching it. It is affirmed that before 1680 Bentley had been instructed in Newton's discoveries by attendance at the master's lectures. Whiston had heard Newton lecture in the public Schools before 1689. And by 1694 a question taken from the philosophy of Newton was defended in the schools by SAMUEL CLARKE of Norwich.

Three years later Samuel Clarke in his translation of Rohault included in his notes so many references to the *Principia*, that when these references were increased in the second edition of 1702, it might truly be said that 'the Newtonian Philosophy, which had already crept into the

notes was soon about to usurp the text and to subjugate the editor, Rohault', in his exposition of the Cartesian philosophy. Dr. Clarke then (in 1706) proceeded to translate Newton's *Opticks* into elegant Latin, a performance which so pleased the author that he gave the translator £100 for each of his five children.[1]

The Rev. WILLIAM WHISTON (1667–1752) of Clare College, was appointed by Newton as his deputy in 1699, and became his successor in 1701, delivering explanatory lectures, which were published in 1707, and in 1710 for his pupils.

He was a well-known and erratic person who had been instituted to the vicarage of Lowestoft in 1698, had organized the first Charity Schools at Cambridge in 1703, was a voluminous writer, and a man of 'very acute but ill-balanced intellect'. Many stories were told of him. Once, when Prince Eugene was visiting England, Whiston printed a new dedication to his Essay on the Apocalypse, in which he pointed out that the prince had fulfilled some of the prophecies. The prince remarked that he 'had not the honour of being known to St. John', but sent Whiston fifteen guineas. Owing to his participation in the religious strife of the time he was expelled from his Professorship in 1710 and from the Church for Arianism.

DANNY, who was tutor to William Stukeley in 1704, 'read in Wells *Arithmetica numerosa et speciosa*, Pardie's *Geometry*, Tacquet's *Geometry* by Whiston, Harris's *Use of the Globes*, Rohault's *Physics by Clark*'.

Public exercises in the Schools or *Acts*, as they are called, founded on every part of the Newtonian system became very common in 1707, and by 1710 it is asserted that copies of the *Principia*, originally published at ten shillings, readily sold at two guineas.

We may perhaps interrupt our story of the spread of the Newtonian philosophy at this point in order to present some idea of the outlook of a young undergraduate of those days, who confessed to be fond of pleasure as well as mathematically-minded. Cambridge owes to him the finest box of mathematical instruments in the University. The Hon. ROGER NORTH came up to Jesus College in 1667.

[1] Whiston, *Historical Memoirs of Clarke*, p. 13; Wordsworth.

In his *Autobiography* he confides to us that his favourite studies were Mathematics and Music.

As for the former, I have dipped in all sorts, so as to be informed of and understand the riddle even in the more abstruse points; but this regards the study, for the mastery of which I have declared myself incompetent. But the practical which is much easier, I dealt in: as geometry and its coherent arithmetic.' . . . [After recounting his early proficiency in Dialling (p. 158), he says] Next, my brother F. N. furnished me with a ruler and a pair of compasses, and *Speidell's Geometry*,[1] which was of great benefit in the practical part, all which I had in common things before I went to the University, when I entered upon formal studying the theoretic. And having read Fournier on Euclid,[2] I wondered at the emptiness of that study, and used to say what a stir is here to prove that one line is equal to another—to what end is it? And troubling my brother often with such talk, he used constantly to say that it was a rule I might depend on in the study of the mathematics, that if I were not pleased I did not understand. This at last set me on work again, and when I once got hold of the thread, and found it come, that is, perceived the drift of the many (seeming) useless propositions tending to prove others of consequence, I devoured the science with great greediness; and this illumination I had upon consideration of the forty-seventh proposition, which is that in all [right angled] triangles the square of the greater [side] is equal to those of the two others. This entered me alive, as I may say, and I digested it with great satisfaction, and having got Barrow, which is much the best,[3] I launched farther and made myself master of so much as served to common practical geometry, but the more abstruse

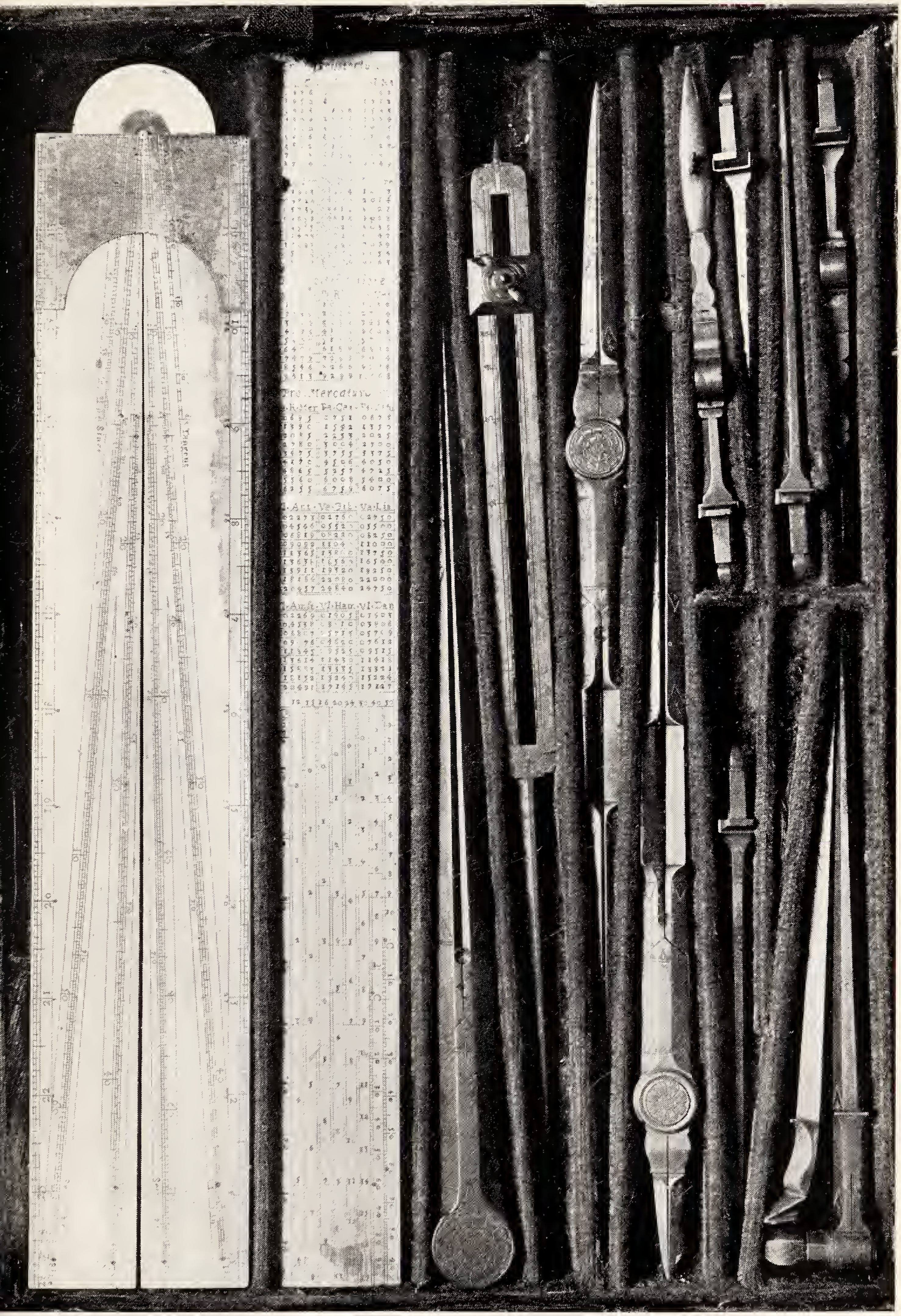
[1] *A Geometrical Extraction, or a compendious Collection of the chiefe and choyse Problemes, collected out of the best and latest Writers* . . . By John Speidell, practitioner in the Mathematics, and professor thereof in London . . . are to be sold at the Author's house in the fields between Princes' Street and the Cockpit. 1617.

[2] George Fournier, S. J., *Euclidis sex priores Elementorum Geometricorum libri demonstrati* . . . Paris, 1644, 12mo.

[3] Dr. Isaac Barrow was Lucasian Professor of Geometry at this time. His *Euclidis Elementa* had been published in 1655, the *Euclidis Data* in 1657.

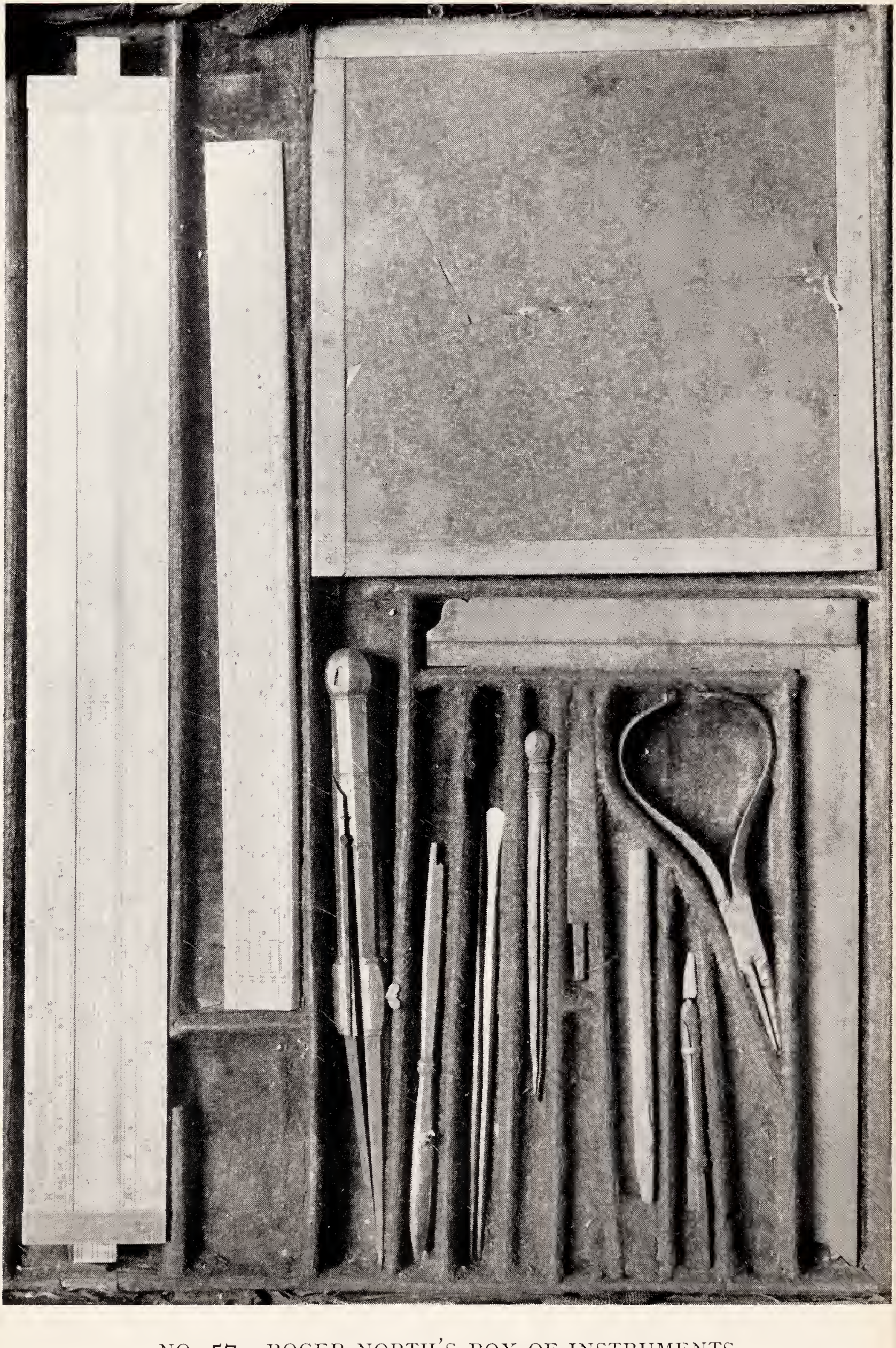
secrets tending to algebra I was not a match for. I had books of ethics and metaphysics also to peruse, but my delight was in philosophy and mathematics, which my brother did not interrupt, being glad that I was employed, and so long did not disturb him with prattle and idle questions. *Logic* I did not touch upon there, having had enough at home, but I improved that by seeing the practice of disputation in the public school and college, and never thought of performing any exercises in public. *Logic is a very dull science,* especially that which relates to disputation, and must be driven by a tutor well versed in it, as a smith hammers iron out of a lump into a bar. And to say truth an age more advanced than ordinary youths fresh in the university is most proper for the study of logic. But in regard that is a time when somewhat must be learnt, and the rules of logic regulate the mind and make it more just to weigh other learning, and although the person neither is delighted nor thoroughly understands the drift nor perhaps the force of what he reads, yet it is fit to be learnt early; for when the mind is more advanced, and comes to work critically upon points of other learning and hath need, memory brings into use the former dull rules, and they are a great help, which else would not at such pinch be at hand. My brother used to recommend to me *translating,* and accordingly I englished Sallust's *Catiline* with some essay of paraphrase, intending to season the style, which is in bare translation dull, with somewhat of English quickness. But this was far from being considerable enough to preserve: however it is a most useful exercise, and fit to be recommended to all students. This is a mixture of language and invention. Exercises which are only of invention torment young minds too much, and after all are not [so] useful as the exercise of language, the readiness and neatness of which prevails more than deep sense.

'And accompanying these studies, if my little cursory reading may be so called, with the practice of invention and drawing, I fell into an humour of contriving new instruments, as well as procuring those of ordinary use, and was never satisfied till I had got a plain table, with a border graduated for holding down paper, and a drawer underneath accomodated to receive all variety of instruments. And with these I did entertain myself many hours, which might have been better and more profitably employed, but I had not power to resist my genius,

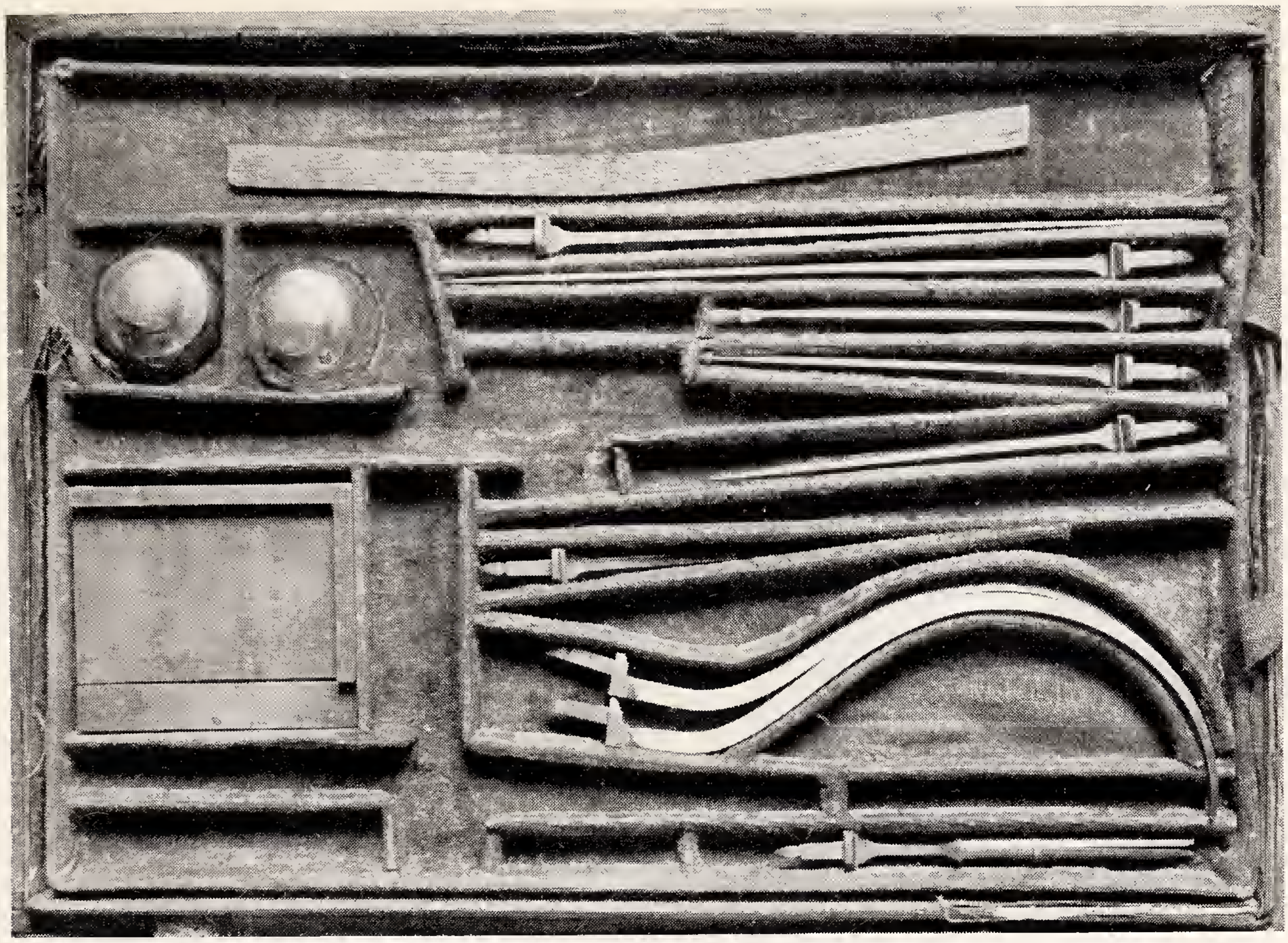


NO. 57. ROGER NORTH'S BOX OF INSTRUMENTS

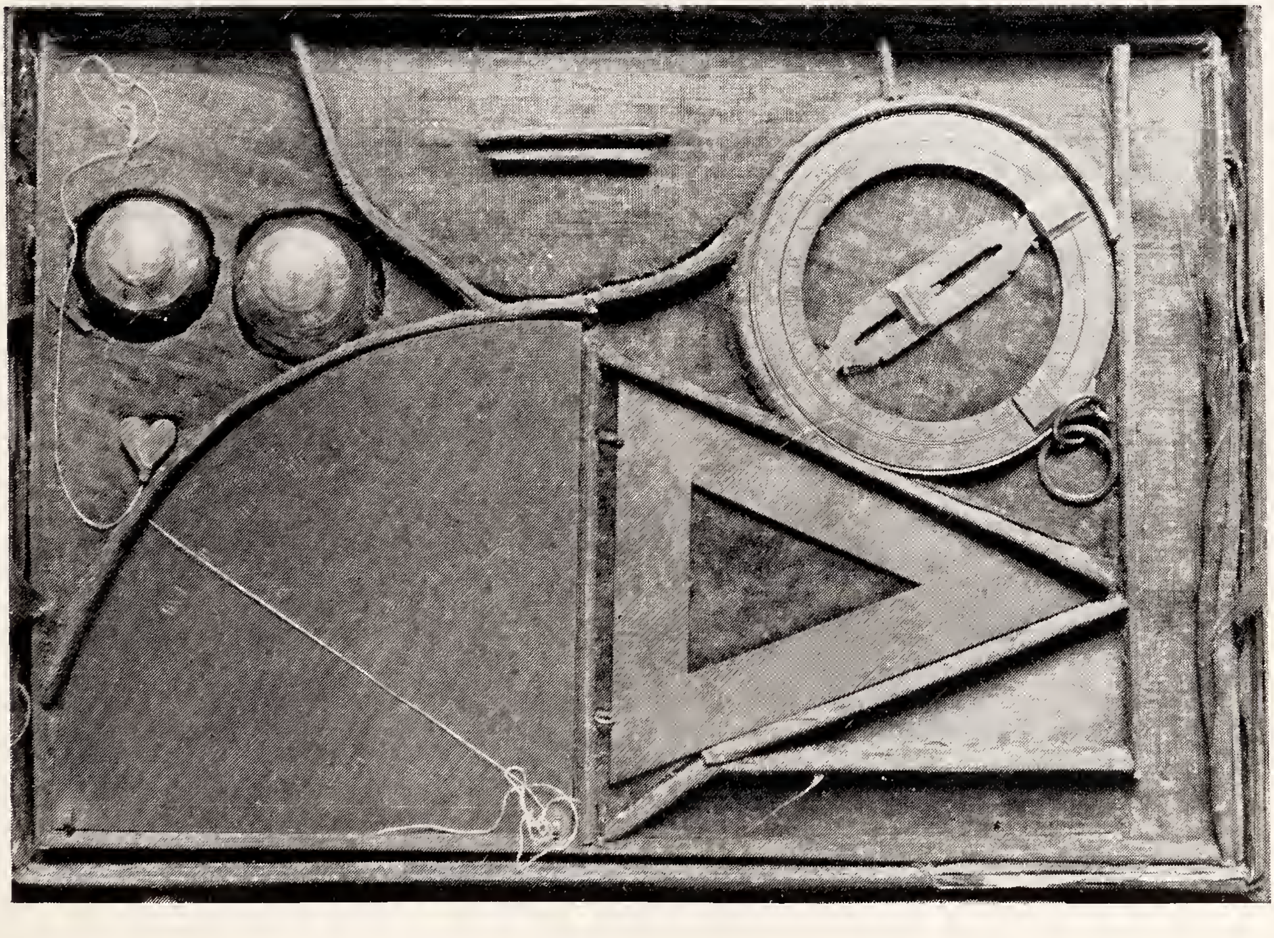
Tray I



NO. 57. ROGER NORTH'S BOX OF INSTRUMENTS
Tray II



Tray III



Tray IV

NO. 57. ROGER NORTH'S BOX OF INSTRUMENTS

and flattered myself that not running into vice I was absolved. But studies are of another place, I am now in my pleasures.'

See also p. 75.

43. Roger North's Box of Mathematical Instruments. c. 1700.

Jesus College.

Roger North (1651–1734) resided for one year as Fellow Commoner 30 Oct. 1667; K.C. 1683; Attorney-General 1685–8; purchased Rougham 1690. His box, measuring $14\frac{1}{4} \times 10\frac{1}{4} \times 4\frac{1}{2}$ inches, is of walnut wood covered with black shagreen, strengthened at the corners with ornamented brass corner-pieces, with handles of gilt brass. Nowhere does any maker's name appear. The foot is $\frac{1}{20}$ inch shorter than the modern foot.

The bottom of the box has a recess $\frac{1}{8}$ inch deep, perhaps for papers. The instruments are arranged in four trays covered with green velvet.

Tray I.

1. 12-inch Ivory Sector engraved with scales of 'Tan., Sines, Secs'. *Rev.* 'Chords, Sec., Lines, Polligons'. *Edge.* 'Versed Sines'.
2. 12-inch Ivory Plotting Scale of (*a*) inches divided to $\frac{1}{10}$ths.
   (*b*) 1/10th of foot divided to 1/10ths and 1/100ths.
   Rev. (*c*) Scales of Chords and of Equal Parts.
   (*d*) Tables of Multiples 1 to 9 of 18 numbers.
   Edge. (*e*) Protractor for the hour lines of a dial, marked '5 to 12' on each side of the mid-line, marked '4'.
3. 12-inch Compasses: washers with incised flower-ornament with 12 and 13 petals.
4. $10\frac{1}{2}$-inch Proportional Compasses inscribed for ratios from '1 to 1' to '1 to 10', with sides fluted for the runners of pivot block.
5. $11\frac{3}{4}$-inch Proportional Compasses for fixed ratio of 1 : 2.
6. 10-inch ,, ,, ,, ,, 1 : 4.
7. $6\frac{3}{4}$-inch 3-legged Compass.

8–10. Two $4\frac{1}{2}$-inch and one $2\frac{1}{2}$-inch Compass points.
11–12. Two $4\frac{3}{4}$-Compass pens with hinges.
The Compasses to which these belonged are lost.

Tray II.

1. Slate in box-wood frame, 5 inches square, graduated on all four sides into inches divided to 1/20ths and 1/24ths.
   (*a*) Boxwood square for use with ditto. (*b*) Slate Pencil.
2. 4-inch Pliers.

3. $6\frac{1}{2}$-inch round-head Compasses with one adjustable point and one changeable point.
   (*a*) Spare point for ditto. (*b*) Pencil holder for ditto.
   (*c*) Pen for ditto missing.
4. Miniature $3\frac{1}{2}$-inch pocket compasses, to screw in tube (missing).
5. Drawing pen for ink.
6. Two pointed brass styles.
7. 12-inch Slide Rule, ivory with silver ends. Scales marked 'Inches, Numbers, Sines', 'M.', 'E.P.'
   Rev. 'Chords. Secant Sines Tangent, Eq. Parts'.
   Edge. 'M.' divided to $\frac{1}{100}$ths of foot. 'Great C'. 'Inches'.
8. $8\frac{1}{2}$-inch Ivory Plotting Scale with diagonal scale divided to $\frac{1}{2}$ inches. Scales of 12, 15, 16, 24, 30, 32; and three Scales of Chords.

TRAY III.

1. Set of 20 Napier's Bones of ivory in box-wood case, with 'virgula' for squares and cubes.
2. Compass points: Two $7\frac{1}{2}$-inch. Two 7-inch calliper points. Two $4\frac{3}{4}$-inch with cutting edge and blunt point. One $4\frac{3}{4}$-inch with sharp point. One 4-inch pencil-holder. One 2-inch sharp point.

TRAY IV.

1. Universal Ring Dial, 4 inches in diameter.
2. $5\frac{3}{4}$-inch Gunter's Quadrant, with heart-shaped plumbob.
3. Semicircular Protractor (missing).
4. Surveyor's Triangle, sides measuring 6 inches, 6 inches, and $4\frac{1}{2}$ inches, with eyelet for attachment of plumbline.
5. Two cut-glass Ink-bottles with silver caps marked IR (? John Reynolds).

44. Roman Compasses from various sites.

Archaeological Museum.

45. 8-inch Callipers. 17th cent.

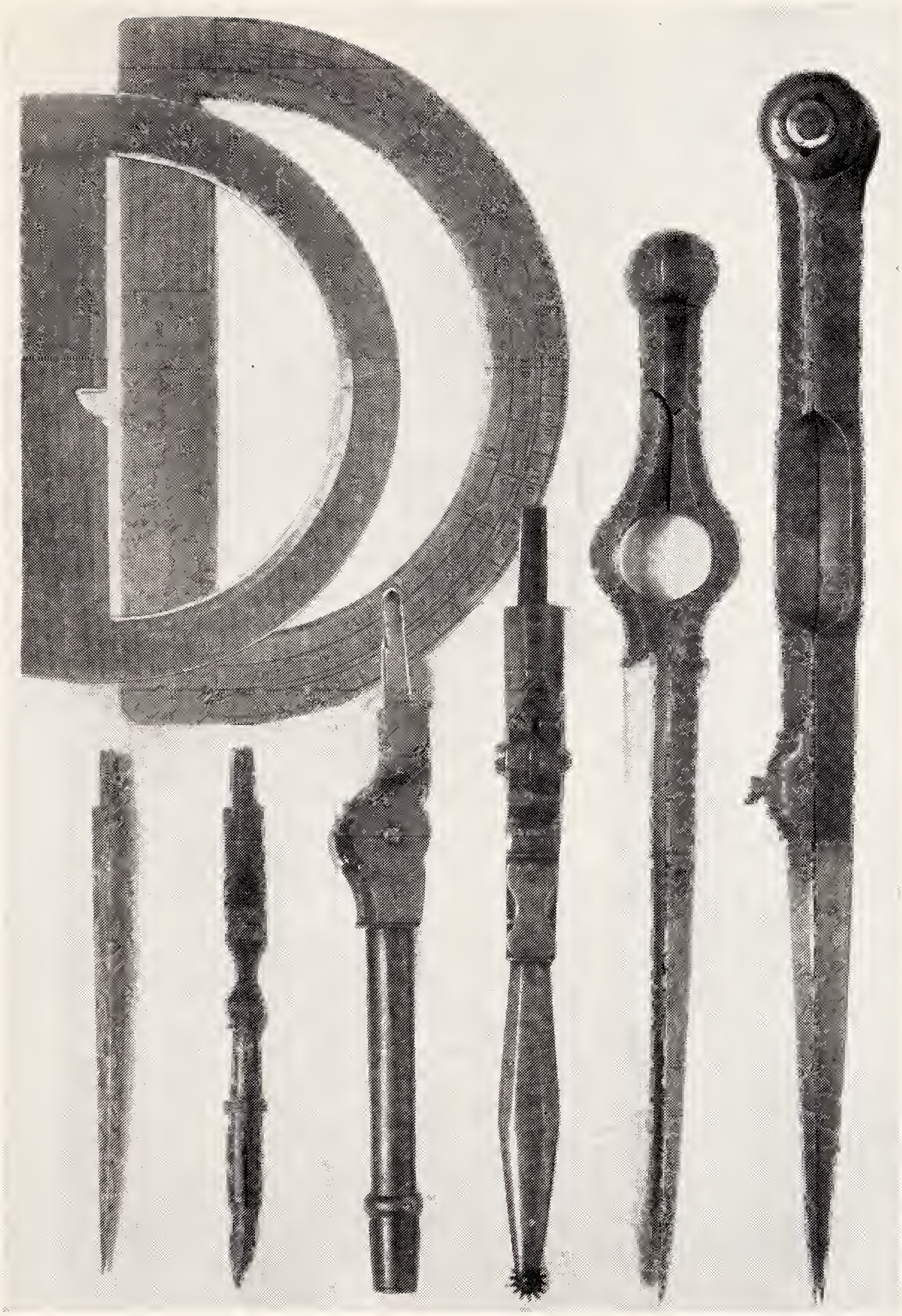
Ex Rosenheim collection in Arch. Mus.

46. 10-inch Compasses. Trinity College.

47. $6\frac{3}{4}$-inch Dividers—round heads and bowed shanks.

48-9. $4\frac{1}{2}$-inch Dotting Pen; $2\frac{3}{4}$- and $3\frac{3}{4}$-inch Pencil Holders; Spare Point for Compass.

These, and other instruments (later accessions) traditionally associated with Newton, are kept in a small oak cabinet labelled 'S^r. Isaac Newton's 1667.' Trinity College.



NOS. 59–67. DRAWING INSTRUMENTS IN TRINITY COLLEGE

50. **$6\frac{1}{4}$-inch Parallel Rulers,** Brass. Trinity College.

51. **$3\frac{1}{8}$-inch radius Semicircular Protractor. c. 1700.**
Trinity College.

52. **$2\frac{1}{2}$-inch radius Semicircular Protractor.**
'I. Rowley Fecit.' Trinity College.

With angular measures marked '4, 6, 12' corresponding to 90°, 60°, 30°.

53. **10-inch Circular Protractor. c. 1800.**
Cavendish Laboratory.

By 'DOLLOND LONDON'.

Fiducial edge divided on the inner side of a 12-inch flat ring of brass. 4 prick points on lower surface.

54. **10-inch Dialling Scale. c. 1660.**
Trinity College.

'H. Sutton fecit, Ex dono Scattergood Arm.'[1]

Obv. 'Cho. Sec. Sin. Tan. Inch.'

Rev.: 'Hours, Declin. Chord, Substile, Stile, Angle, Inclin. Merid.'

55. **12-inch Plotting Scale,** Brass. **c. 1700.**
'I. Rowley Fecit.' Trinity College.
Obv. 'I[nches] M[easure] F. M[$\frac{1}{10}$th of foot]. Chords.'
Rev.: 'T. N. S. M. EP. EP Hours, Lon. Cho. Sin. Tan. H. T.'

56. **6-inch Brass Plotting Scale.**
Trinity College.

'E. Culpeper Londini fecit' in tiniest script across end. 'Trin. Coll. Cant. Ex dono Tho. Scattergood Arm.'[1]
Scales of 'Sin. N.S. VS.'

57. **24-inch Navigator's Plotting Scale. 19th cent.**
Silver 25 in. × 2 in. 'A. Sloper, Maker, New Kent Road, London.' Trinity College.

Pres. by Lancelot Feilding Everest, M.A., LL.D., Trin.

[1] These early instruments date from the period when Samuel, son of Anthony Scattergood (D.N.B.), was up at Trinity, but the relationship of Thomas to them is as yet uncertain.

Coll. Camb., 8 Dec. 1917, in memory of Sir George Everest his father.

Scales marked 'S. Rhumb, Numb., SQR, SC, S Sec., Ver. Sines, Tangent, Meridian, Num. Root, Num. Cube.'

R : Dist :: S.C. : Dep :: SCC : D Lat
D Lat : Dep : Tan 45 : T course
SC Mid : Lat : Dep :: R : D Long
D Lat : Dep :: MD Lat : D Long
SCL : SO Dec :: R : SO Amp.

58. 9-inch Brass Sector. c. 1640.

'Ex dono Tho. Scattergood Arm. Trin. Coll. Cant.'

With cross bar and Lines of Metals. Engraving not unlike Allen's work.

59. 9-inch Sector. 1660.

Trinity College.

'H. Sutton fecit 1660, Ex dono Scattergood Arm.'

Built of 3 brass plates held together by 38 rivets.

Obv. Scales marked 'S, T, T, S, and Vs.'

Rev. 'C. S. L. N[umbers]'. *Outer edge* scale of 'T'.

Cross plate engraved with Diagonal Plotting Scale on one side and Calendar on other.

60. 9-inch Wooden Sector.

Trinity College.

Obv. 'S. T. Tan Chords Latt Sin Tan.'

Rev. 'Hours C. L. S. Num.' *Edge*: Scale of Inches.

61. 12-inch Sector. 1703.

'I. Rowley Fecit 1703, Colleg. Trinit. Cantab.'

Obv. 'Cho. Sec. Lin. Numbers'.

Rev. 'Tan. Tan. Sin. Sin Tangents.'

Edge: Scales of Inches and of $\frac{1}{10}$ths of foot.

62. 18-inch Sector. 1703.

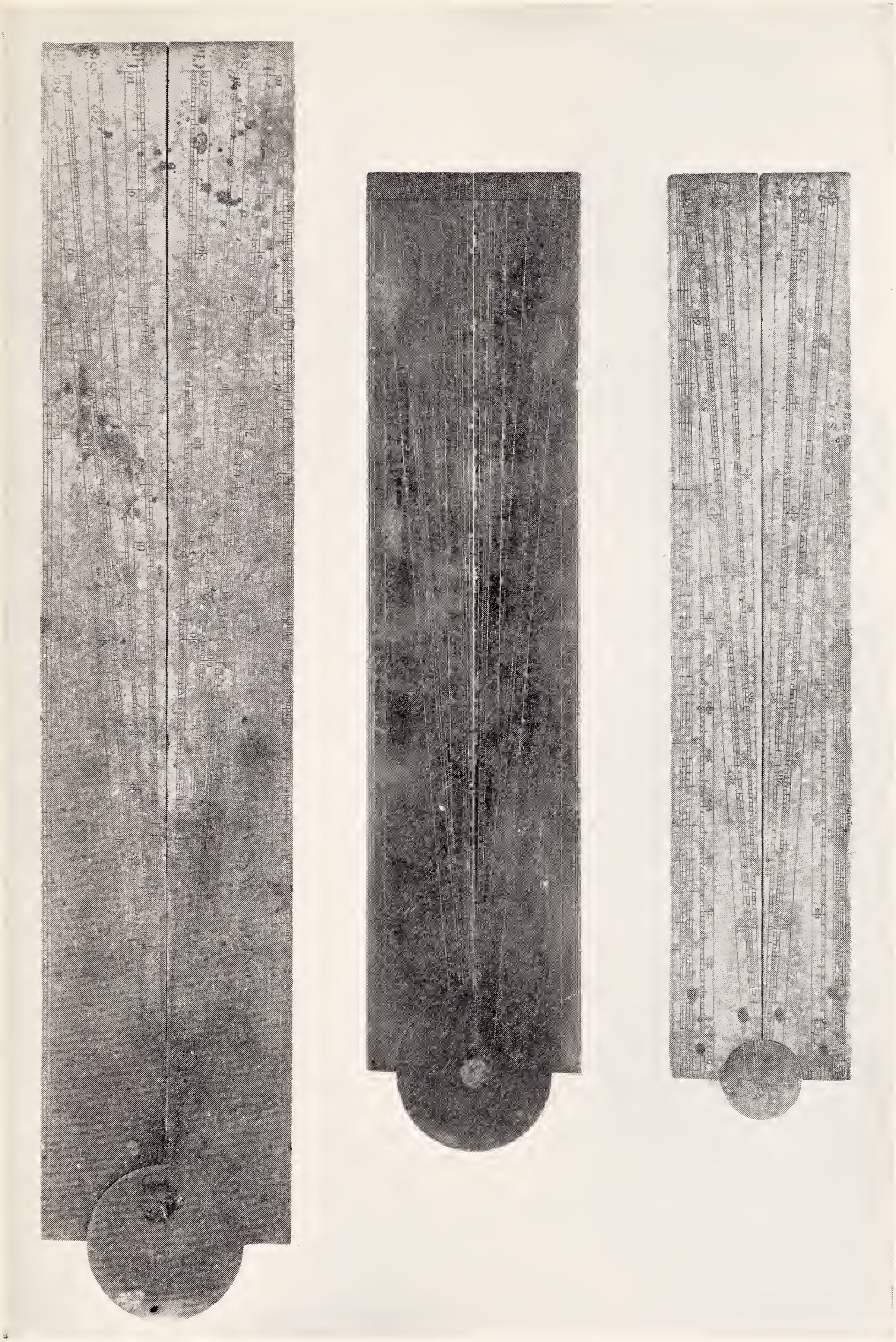
'I. England, Charing Cross, Londini Fecit 1703, Colleg. Trin. Cantab.'

Obv. 'Cho. Sec. Lin. poll'

63-66. Four 6-inch French Sectors, Brass. **18th cent.**

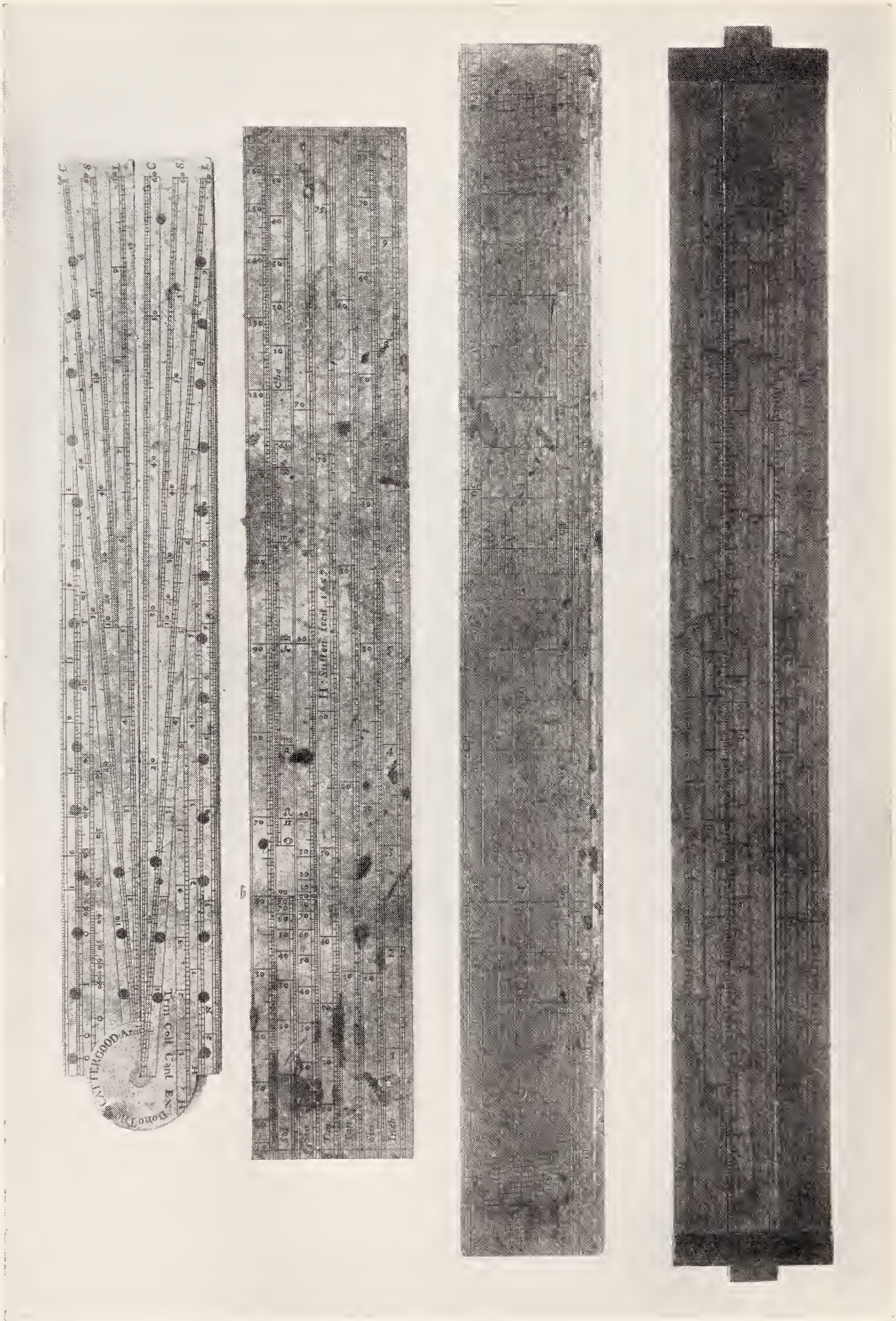
(*a*) '*Clerget A Paris au Butterfield.*' Arch. Mus.

(*b, c, d*) By *Butterfield, Langlois* and *le Maire.*



61 58 60

SECTORS IN NEWTON'S CABINET



29 54 55 68

RULES IN NEWTON'S CABINET

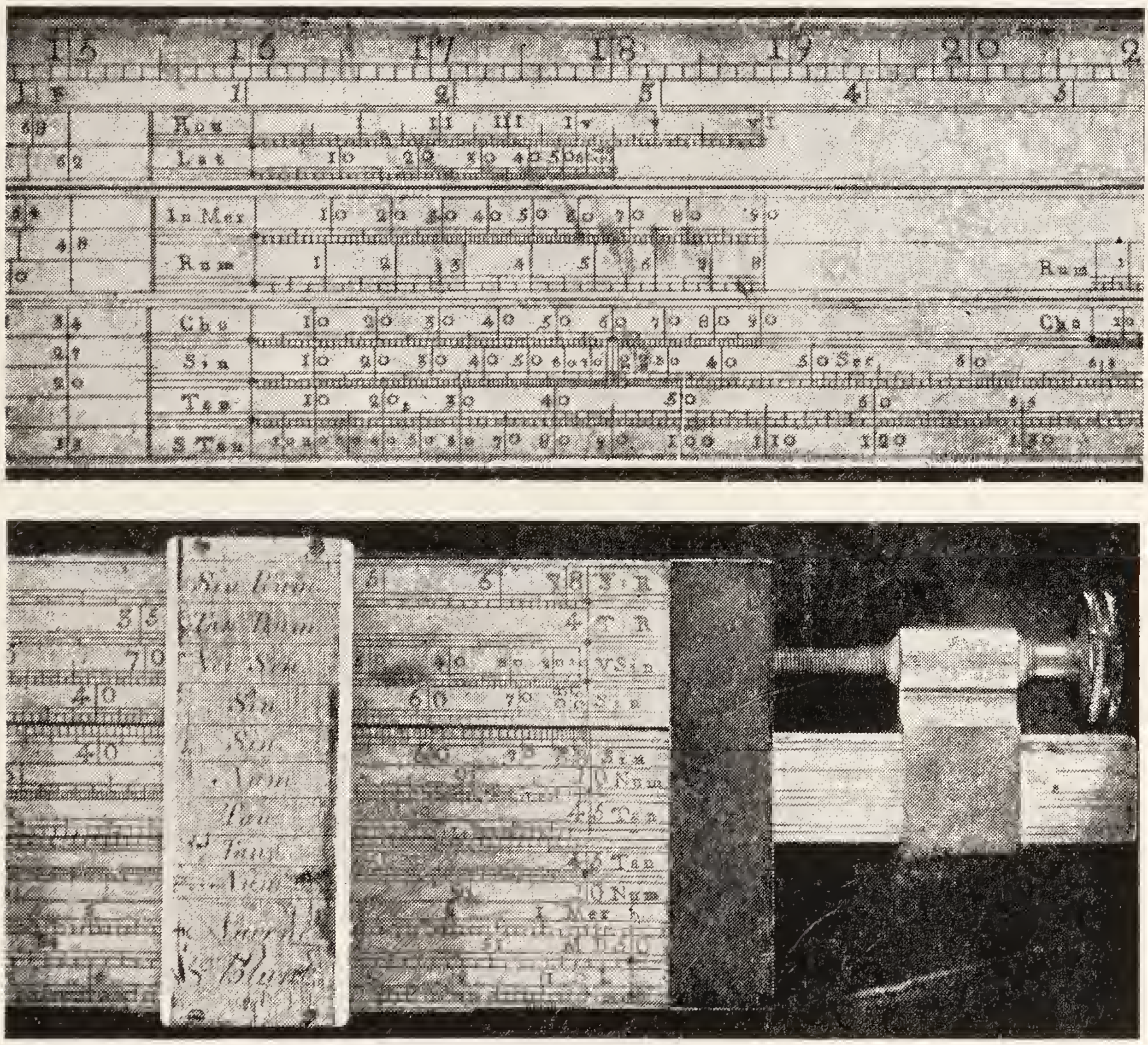
67. 7-inch Gunners' Callipers. c. 1700.
By '*Butterfield A Paris*'. Prof. A. Hutchinson.

68. 12-inch Slide Rule.
Trinity College.

Boxwood with brass ends.
Scales marked 'E P, M, T, N, SR, S, C.R.'
'Leag. M. Lon.'

69. Navigator's Slide Rule. Length, 2 ft. 9 in.
Cavendish Laboratory.

Signed 'Nairn & Blunt' on brass slider. A flyleaf signed by T. D. A. 1837, states that it was sold by W. Cary, 181 Strand, and was used on board *The Lady of St. Kilda* yacht.



Face marked with scales 'Sin Rum, Tan Rum, Ver Sin, Sin, Sin, Num, Tan, Tan, Num, D Mer, Mer Con, Mer. M D, D L'.

Back. Scales of ordinary feet and inches and of Sea feet and inches. 'Hou[rs], Lat, In Mer, Rum, Cho, Sin, Sec, Tan, S[emi] Tan, M: Lon.'

70. 12-inch Gauger's Slide Rule. c. 1816.
Cavendish Laboratory.

Ivory: by 'Bate, London.'

Inscribed: 'Per cent under Proof' 'Sikes's Proof P' 'Over Proof' 'Indication'.

On back: 'Thermometer scale'. 'Percent over Proof.'

71-74. 12-inch Gauger's Slide Rules. 1816.
Cavendish Laboratory.

Boxwood: Four examples inscribed by Wollaston 'Original' and 'From Excise Office July 1816'

(*a*)	Stamped 'Per cent	below	R'	and	'above	R'.
(*b*)	,,	,,	D'	,,		D'.
(*c*)	,,	,,	over Proof'	,,		Proof'.

75. 12-inch Slide Rule for Exchanges, Bullion, &c. 1813.
Cavendish Laboratory.

Showing Percentages above and below par.

Published by W. Cary 182 Strand. Apr. 1, 1813.

Among the foreign exchanges given are

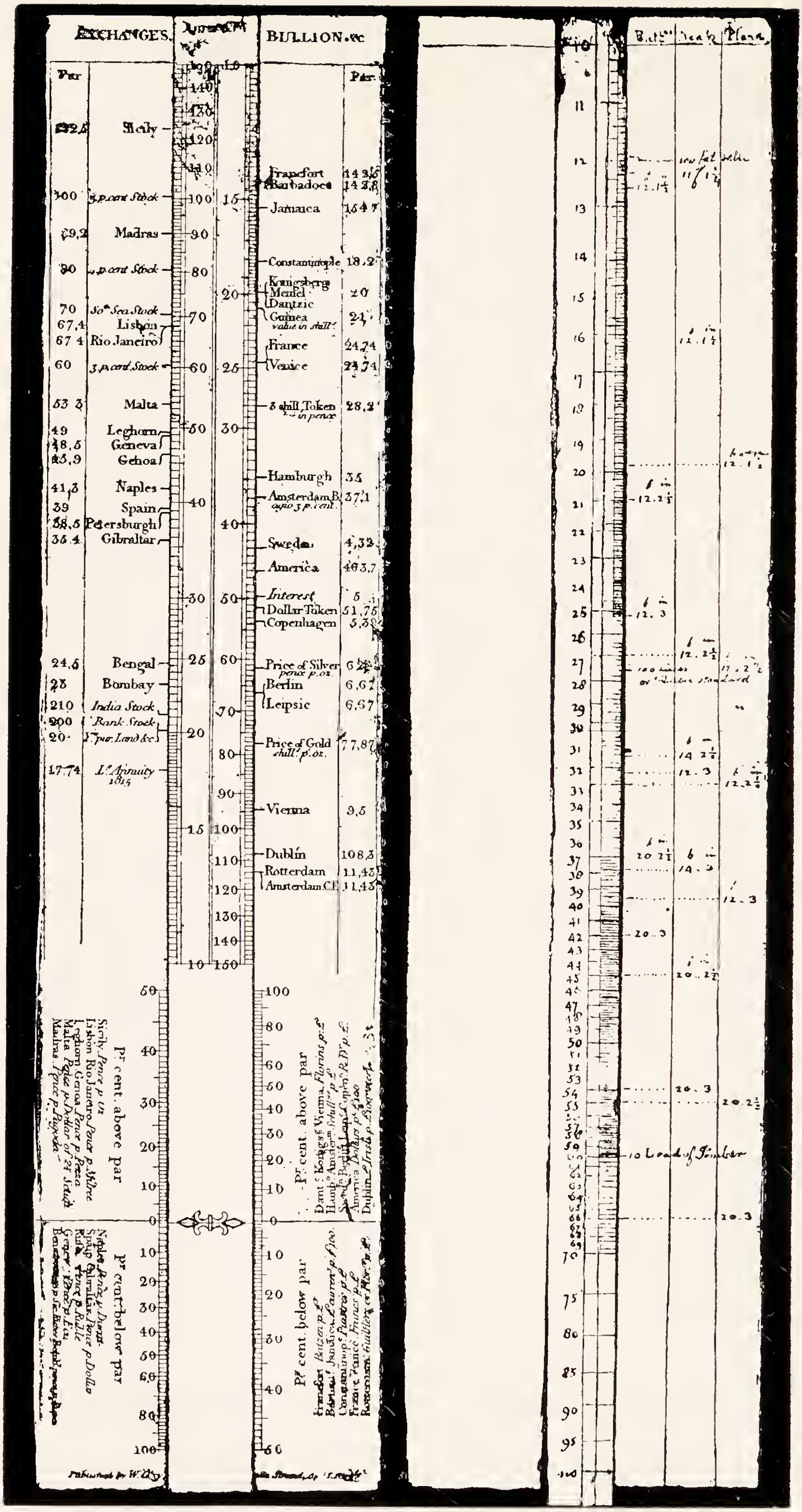
Sicily, Pence per Oz.
Lisbon, Rio Janeiro, Pence p. Milree.
Leghorn, Genoa, Pence p. Pezza.
Malta, Pence p. Dollar of $2\frac{1}{2}$ Scudi.
Madras, Pence p. Pagoda.
} Above par.

Naples, Pence p. Ducat.
Spain, Gibraltar, Pence p. Dollar.
Russia, Pence p. Ruble.
Geneva, Pence p. Ecu.
Bengal, Pence p. Sic Rupee.
Bomb[y], Pence p. Rupee.

On the *Back* Wollaston has affixed a paper inscribed with a Timber Scale for estimating quantities of Battens, Deals and Planks

83 84 85 81 82

NOS. 81–5. WOLLASTON'S GAUGER'S SLIDE-RULES



No. 86. Banker's Slide-Rule. Timber Merchant's Slide-Rule

Roger Cotes (1682–1716), fellow of Trinity College, was chosen to be the first occupant of the Plumian chair of Astronomy (1707/16). He was, as we have seen, a great forwarder of the Newtonian philosophy. For four years (1709–13) he edited the second edition of the *Principia*, a service which may have shortened his life, but which educed the encomium from Newton that 'had Cotes lived we might have known something'.

His writings were posthumously published in 1722 under the title *Harmonia Mensurarum, sive Analysis et Synthesis per Rationum et Angulorum Mensuras promotae; accedunt alia Opuscula Mathematica, edidit et auxit* Robertus Smith. Cantab. 1722.

De Morgan called this 'the earliest work in which decided progress was made in the application of logarithms and of the properties of the circle to the calculus of fluents'. It was also the first complete treatise on the integral calculus, and in it first appears the well-known theorem in trigonometry, known by his name, which depends on the forming of factors X^n-1.

A volume of *Opera Miscellanea* was printed in the same year, and contains the earliest attempt to frame a theory of Errors. Other essays deal with Newton's *Methodus differentialis*; with the descent of a body under gravity; with the cycloidal pendulum and with the flight of projectiles. His unfinished theory of partial fractions was completed by de Moivre who chose England as his adopted country.

The movement was further fostered in the University by Richard Laughton (adm. Clare 1680, d. 1723) when, he having become proctor in 1709–10, presided in the schools as moderator. He had previously published (c. 1707) 'a sheet of questions for the use of the Soph Schools' on the mathematical Newtonian philosophy. At Clare Hall too, where as tutor he gave lectures on Newtonian principles, 'the credit and popularity of his college had risen very high' by 8 July, 1714 (Thoresby's *Diary*).

On the other hand, another tutor of Clare, Robert Green, opposed the Newtonian philosophy in his *Principles of Natural Philosophy*, 1712. Perhaps his opposition led to the idea that the Newtonian philosophy was studied

in other Universities more effectively than in Cambridge At Edinburgh the three Gregories all threw their influence into the Newtonian scale, and the good work was continued by Professor Colin Maclaurin (1698–1746), the author of a *Treatise on Fluxions* 1742 and *An Account of Sir Isaac Newton's Philosophical Discoveries* 1748.

On October 23, 1710 Wm. Whiston, the third Lucasian Professor, was cited to appear before the Vice-Chancellor and nine Heads of Colleges for publishing and avowing Arian tenets. And on October 30 he was banished from the University and removed from his professorship. After his expulsion he gave astronomical lectures 'at Mr. Button's Coffee house, near Covent Garden, to the agreeable entertainment of a good number of curious persons and the procuring me and my family some comfortable support under my banishment'. He was succeeded by Nicolas Saunderson (1682–1739) of Christ's College, who held the chair with the approval of all until his death at the age of 56 in 1739. Saunderson was a potent missionary of the new learning, as well as one of the least expected. He had settled in Cambridge with the object of forwarding Newtonian studies, an object which he achieved with miraculous success—miraculous because he had never seen what he taught. He was quite blind: at the age of one year smallpox had destroyed his eyes.[1] But his assiduity in acquiring mathematical knowledge led to his winning the regard of Newton, the encouragement of Whiston, and the attendance of students at his private lectures. Even the deposed Whiston approved of his course on 'The Principia, Optics and Arithmetica Universalis of Newton'.

A manuscript copy of Saunderson's lectures taken in 1725 by Jacob Wragg of Emmanuel College, B.A. 1726, Fellow 1929, and afterwards Rector of North Cadbury, Somerset, is preserved with the Lewis Evans Collection of Scientific Instruments at Oxford.

In London, Brook Taylor (1685–1731), a most noteworthy member of St. John's, was serving the Royal Society as Secretary for four years, 1714–18, during which

[1] An engraving of the blind Saunderson handling an armillary sphere was executed by G. Van der Gutch from a painting by Vanderbanck.

...nderson's Hydrostaticks.

Sr Isaac Newton has given this Definition of a Fluid:
"Fluidum est Corpus cujus partes vi cuicunq illatæ cedunt et Cedendo facile Moventur inter se."
By a Fluid is meant yt body whose parts yeild to any force impress'd on em, & thereby are easily put into Mo:tion. If this impress'd force affects ye body equally, ye fluid yn will remain unmov'd, & can't be suppos'd at all to give way; But if ye pressure on ye sides of ye Fluid is unequall, (Especially if ye Fluid is Incapable of being Condens'd) ye Particles of ye Fluid will then Easily slide over one another, & yeild to ye side where ye Pressure is strongest. 'Tis very much Doubted whether there be any such thing in Nature as a Perfect Fluid; by wch is Understood such a one as yeilds to & is put into Motion by ye least Impress'd force imaginable. That there's no such thing seems probable: 1st from Expe:rience, in these Fluids wch we are conversant withall: As water, Quicksilver, &c. None of wch (as appears by Experi:ments) have so great Fluidity as a perfect Fluid requires. 2ly. ye Improbability of such a Fluid may be prov'd from ye Different Degrees of Consistency in Bodies: as a Diamond is More Consistent yn a Stone; a Stone more yn Wood; Wood more yn Cork, Cork more yn Butter, Butter more yn Honey, Honey more yn Oyl, Oyl more yn Water, & so on. Now ye two Extreems of Consistency ought to be perfectly Consis:tent, & perfectly Fluid; but there's no such thing, as we know of: as a body perfectly hard or Consistent. Therefore 'tis probable on ye other hand that there's no such thing as a body perfectly Fluid. —

Published by Harrison & Co. Jan. 1. 1796

DR. SAUNDERSON.

THAT most extraordinary mathematician, Dr. Nicholas Saunderson, was the son of an officer of the excise, and born in 1682, at Thurlston in Yorkshire. When he was a year old, the small-pox deprived him not only of his sight, but of his eyes, which came away in abscesses, so that he retained no more idea of light and colours than if he had been blind at his birth.

Being sent early to a free-school at Penniston, he made astonishing progress in the Greek and Latin languages; and, having compleated his grammar-learning, his father began to instruct him in arithmetick. It was now that his genius appeared; for the pupil soon excelled his preceptor, and penetrated all the depths of the mathematicks.

At length, in consequence of excessive thirst for science, and being unable to settle at the University as a student, he was advised to commence teacher of the mathematicks at Cambridge. His fame, in a short time, attracted general notice. Sir Isaac Newton's Principia Mathematica, Opticks, and Arithmetica Universalis, were the foundations of his lectures, and they afforded a noble field for the display of his transcendant abilities.

Though Sir Isaac Newton had quitted Cambridge, he greatly interested himself in the elevation of Saunderson; who, in 1711, was made Lucasian Professor of the mathematicks, and delivered his inauguration speech in a truly Ciceronian stile of very elegant Latin. From this period, he devoted his whole time to reading his lectures, and instructing his pupils.

In 1728, when **George II.** visited the **University**, he signified his desire to see so extraordinary a person; and, on the professor's attending his Majesty in the Senate House, he was, by royal favour, immediately created doctor of laws.

time he contributed many papers to the *Philosophical Transactions*, including such subjects as the theory of projectiles, the centre of oscillation, capillary attraction.

His principal work was the *Methodus Incrementorum Directa et Inversa*, 1715, in which he dealt with the theory of the transverse vibration of strings, and found that the number of half-vibrations per second is $\pi\sqrt{\frac{DP}{LN}}$ where $D =$ length of a seconds pendulum, $P =$ stretching force, $L =$ length of string and $N =$ weight of string.

The earliest determination of the differential equation of the path of a ray of light when traversing a medium of varying density is included in the same work. Ball considered him to have been 'the creator of the theory of finite differences', and to have formulated the earliest general enunciation of the principle of vanishing points: see his treatise on perspective 1719.

The fifth Lucasian professor, the Rev. John Colson of Emmanuel, had been master of Rochester School 1713. He is remembered as the editor of *Newton's Fluxions* 1736, and for deciphering Saunderson's *Elements of Algebra*, which was prefixed to the posthumous *Algebra* in 1740. Cf. Cooper, *Biographical Dictionary*. He held the Lucasian Professorship from 1739 to 1760.

1750–1800

The mention of Algebra recalls the fact that on 30 Sept. 1706 Mary wife of Sir Edwin Sadleir Bart. of C.C.C. and widow of William Croune, M.D., of Emmanuel, provided by will for the establishment of Algebra lecturers in 17 colleges, and that in the selection Dr. Croune's kinsfolk were to have preference. Such lectures were endowed in 9 colleges, the remainder not becoming similarly endowed until 1802. It is therefore of interest to note that there is no special mention of Algebra in a summary of the state of Mathematical teaching in Cambridge drawn up in 1750, at a time when even in the best boys' schools in England mathematics were not being taught.

In no college were these algebra lectures more successful

than at St. John's. They began in 1712, and were held by John Newcome, Phillip Williams and Caleb Parnham (1730), who had been 'Lector Mathematicus in Perspectiva', Arthur Prince (1739)—the last of the series having been the Rev. J. R. Lunn, who was not replaced, because the University Commission of 1850 confiscated the endowment to make a new Professorship of Mathematics and to augment the stipends of the other existing chairs—a most 'flagrant act of robbery' and not in accordance with the desire of the founders.

Mathematicks and Natural Philosophy are so generally and so exactly understood, that more than 20 in every year of the Candidates for a Batchelor of Arts Degree are able to demonstrate the principal Propositions in the *Principia*; and most other books of the first Character on those subjects. Nay, several of this number, they tell you, are no strangers to the *Higher Geometry* and the more difficult parts of the Mathematicks: and others who are not of this number, are yet well acquainted with the Experiments and Appearances in natural Science. (J. Green, *Academic*, 1750, p. 23.)

An eminent algebraist of this period was baron Francis Maseres (1731–1824), fellow of Clare 1756–9, author of *A Dissertation on the Negative Sign in Algebra* 1758, who set himself against Saunderson and others, for they rejected negative quantities -1, and $\sqrt{-1}$, and, as De Morgan aptly puts it, 'made war of extermination on all that distinguishes algebra from arithmetic'. In this endeavour he was joined by William Trend. Their leading idea 'seems to have been to calculate more decimal places than any one would want and to reprint the works of all who had done the same thing' (*Astron. Soc. Monthly Notices*, v. 148). Maseres publications comprised:

1. *Dissertation on the use of the Negative Sign in Algebra.* 1758.
2. *Elements of Plane Trigonometry.* 1760.
3. *Scriptores Logarithmici*, 6 vols. 1791–1807.
4. *Doctrine of Permutations and Combinations.* 1795.
5. *Appendix to Trend's Principles of Algebra.* 1798.

6. *Tracts on the Resolution of affected Algebraick Equations by Halley's, Raphson's and Sir Isaac Newton's Methods of Approximation.* 1800.
7. *Tracts on the Resolution of Cubick and Biquadratic Equations.* [1803.]
8. *Scriptores Optici.* 1823. A reprint of writings of James Gregory and others.

Also papers in *Phil. Trans.* for 1777, 1778, and 1780.

EDWARD WARING (Magdalene), was appointed 6th Lucasian professor in 1760 at the age of 25. He contributed the *Miscellanea Analytica de Aequationibus Algebraicis et Curvarum Proprietatibus, Meditationes Algebraicae, Meditationes Analyticae.* This work was controverted by Dr. Powell of St. John's, and in his reply Waring benefited by the assistance of J. WILSON, then an undergraduate of Peterhouse. Wilson 'of the Theorem' was senior wrangler in 1761, became Paley's private tutor and afterwards a Judge of Common Pleas.

A volume of *Excerpta quaedam e Newtoni Principiis Philosophiae Naturalis* with notes, appeared in 1765 under the joint editorship of G. WOLLASTON (Sidney), J. JEBB, and R. THORP (Peterhouse) and was used as a standard work for many years.

The literary activities of the afore-mentioned professors and teachers were praised, and the omission of lectures was explained by Dr. Parr.

'Dr. Waring and Mr. Vince [Caius, Plumian Prof. 1796] in their writings have done honour to the science, not only of their University but of their age. The profound researches of Dr. Waring were not adapted to any form of communication by lectures. But Mr. Vince has, by private instruction, been very useful both to those who were novitiates and to those who were proficients in mathematics. Dr. Hallifax, Dr. Rutherford, Dr. Watson very abundantly conveyed the information which belonged to their departments, sometimes in the disputes in the schools, and sometimes by the publication of their writings.'

THOMAS RUTHERFORD (1712–71) (St. John's), *Ordo Institutionum Physicarum*, Camb. 1743. *On the Nature and Obligations of Virtue* 1744. *System of Natural Philosophy, being a Course of Lectures in Mechanics, Optics, Hydro-*

statics, Astronomy, read in St. John's College, 2 vols., 1748. 31 pls. He then became Regius Professor of Divinity 1756–71. F.R.S.

Israel Lyons (1739–75) must have been an interesting character. He was born at Cambridge, the son of a Polish Jew of the same name. In early life he showed such great aptitude for mathematics that Dr. Robert Smith, the then Master of Trinity, offered to put him to school at his own expense, but Israel only went for an hour or two a day, saying that he could learn more by himself in an hour, than with his master in a day.

In 1755 he began to study Botany and collected much material for a Flora Cantabrigiensis. In 1758 he published a *Treatise on Fluxions* dedicated to Dr. Smith; followed in 1763 by a *Fasciculus Plantarum circa Cantabrigiam nascentium quae post Raium observatae fuere.* In July 1764 he read a course of lectures on Botany at Oxford, at the suggestion of Mr. Joseph Banks, whom he first instructed in that science.

In 1773 he was appointed by the Board of Longitude to proceed with Captain Phipps (afterwards Lord Mulgrave) to the North Pole. He had £100 per annum for calculating the Nautical Almanac, and frequently received presents from the Board of Longitude for his inventions.

He was married in March 1774 to Phoebe, da. of Newman Pearson of Over, at St. Martin's in the Field, and died in the following year.

His *Calculations in Spherical Trigonometry abridged* are in the *Philosophical Transactions*, lxi, and after his death his name appeared on the title-page of *A Geographical Dictionary*, to which the Astronomical part was added from his papers.

The trend of mathematical teaching during the second half of the eighteenth century was very different from that which succeeded it in the nineteenth, when the Analytical Society took Cambridge mathematics in hand. The following examples give a good impression of the standard.

T. Robinson of Trinity was seventh wrangler in 1772, but though 'well acquainted with natural philosophy', was little so with analytics, and was given credit for his

superior reasoning powers rather than for 'any great proficiency in Algebra and Fluxions'.

On another occasion the tutor (Turner) of Pembroke Hall advised one of his pupils 'By all means do not neglect your *duodecimals*. I was Senior Wrangler in 1767 by knowing my duodecimals'. Strange as it may now appear, men about this time were actually being prevented from reading too high—'in quaecunque recondita, quaecunque sublimia, impetu quodam fervido ruentibus'—advice that was taken to heart by WAKEFIELD, second wrangler, who in 1776 retired from competition for the Smith's prizes because he 'was but a humble proficient in the higher parts of *Algebra* and *Fluxions*'.

Candidates in 1779 were informed that they would get no credit for advanced subjects unless they satisfied the examiners in Euclid and elementary Natural Philosophy. About 1780 success in examination was ensured by intensive study of *Syllabuses*, called 'College Manuscripts' in later days, which were succeeded by the standard works of Wood and Vince.

In January 1785 Gunning of Christ's perfected himself in the first six books of Euclid and made considerable progress in algebra. Maclaurin was his only text-book, but another undergraduate, Hartley, furnished him with a manuscript which proved an excellent commentary and abounded with examples in which Maclaurin was very deficient.

SAMUEL VINCE the Plumian professor was the author of several much-read text-books on *Conic Sections* 1781, *Trigonometry* 1800, and on *Hypotheses of Gravitation* 1806. He had previously contributed an *Investigation of the Principles of Progressive and Rotatory Motion. Phil. Trans.* 1780, and papers on the *Summation of Infinite Series*, *Experiments on Friction*, and *On Motion and Resistance of Fluids* 1799.

The WORDSWORTH who became 10th wrangler in 1796 read 'Trigonometry . . . Ratios and Variable Quantities . . . copied a syllabus of Mechanics (belonging to a friend) . . . Astronomy. Euclid XI . . . Spherical Trigonometry . . . Vince's Conic Sections . . . Plane Trigonometry . . . Fluxional Problems . . . Cotes, Newton's Opticks . . . Hydrostatics'.

It is not always easy to obtain the undergraduate's view

of his studies. One, however, Samuel Settle in 1797, towards the end of his academical career wrote: 'I am tired of Cambridge studies, and I am persuaded I shall always consider my time spent in Mathematics the least beneficial of any employed in the whole course of my life. Had I been engaged in searching the Scriptures, in composing sermons, . . . I should then have possessed some useful knowledge on going forth into the world.'

Isaac Milner (Queens'; senior wrangler 'incomparabilis' 1774) succeeded Waring as Lucasian Professor, 1798–1820. He did not lecture, but gave informal instruction, and examined. He had been first Jacksonian Professor of natural philosophy, 1783–92, President of Queens', 1788, and Dean of Carlisle.

The course of reading prescribed for those who might desire to obtain high honours in mathematics in the second decade of the 19th century is illustrated by the list of books read by John M. F. Wright of Trinity about 1815–18. He had come up having read Ludlam's *Elements* and Walkinghame's *Tutor's Assistant*.

In his *First Year* he continued with Wood's *Algebra* with Ludlam or Bridge; Woodhouse, *Plane Trigonometry*; and he learnt to write Newton's Binomial Theorem.

Second Year. Old exam. papers, 'College MSS.', problems in Bridge's *Mechanics*.

Wood, Parkinson and Gregory on *Statics* and *Dynamics*.

Wood, *Algebra* Parts II–IV and *Spherical Trigonometry*; Garnier, *Algebra* and *Analyse Algébrique*, Lacroix, *Algebra*, Cresswell, *Spherics*, Leybourne's *Mathematical Repository*, Dodson's *Repository*. He compiled a 'College MS.' of book-work and read Conic Sections. Popular and Plane Astronomy in Bonnycastle, Laplace, *Système du Monde*, Newton's *Principia*, Sect. I, II, III.

Third Year. The Jesuit's *Newton*; Monge, *Géométrie Analytique*; Lagrange, *Mécanique Céleste*; Vince, Dealtry, Lacroix, *Fluxions*; Françœur, *Mécanique* and *Mathématiques Pures*; Poisson, Garnier, Gergonne *Annales Mathématiques*, *Journal Polytechnique*; Leybourne, *Mathematical Repository*, Old papers, the 'small Lacroix' and his three large 4tos; Bossut, *Hydrostatique* and *Hydrodynamique*.

He also attended lectures: Farish on Machinery, Clarke on Mineralogy, and S. Vince (Plumian Professor) on Experimental Mechanics, Hydrostatics, Optics, Astronomy, Magnetism, Electricity, Galvanism, &c.

It has been observed that an estimable spirit of loyalty at Cambridge to the great achievement of Newton 'paralysed that great University for nearly a century', by compelling too rigid an adherence to the details of Newton's formal procedure.

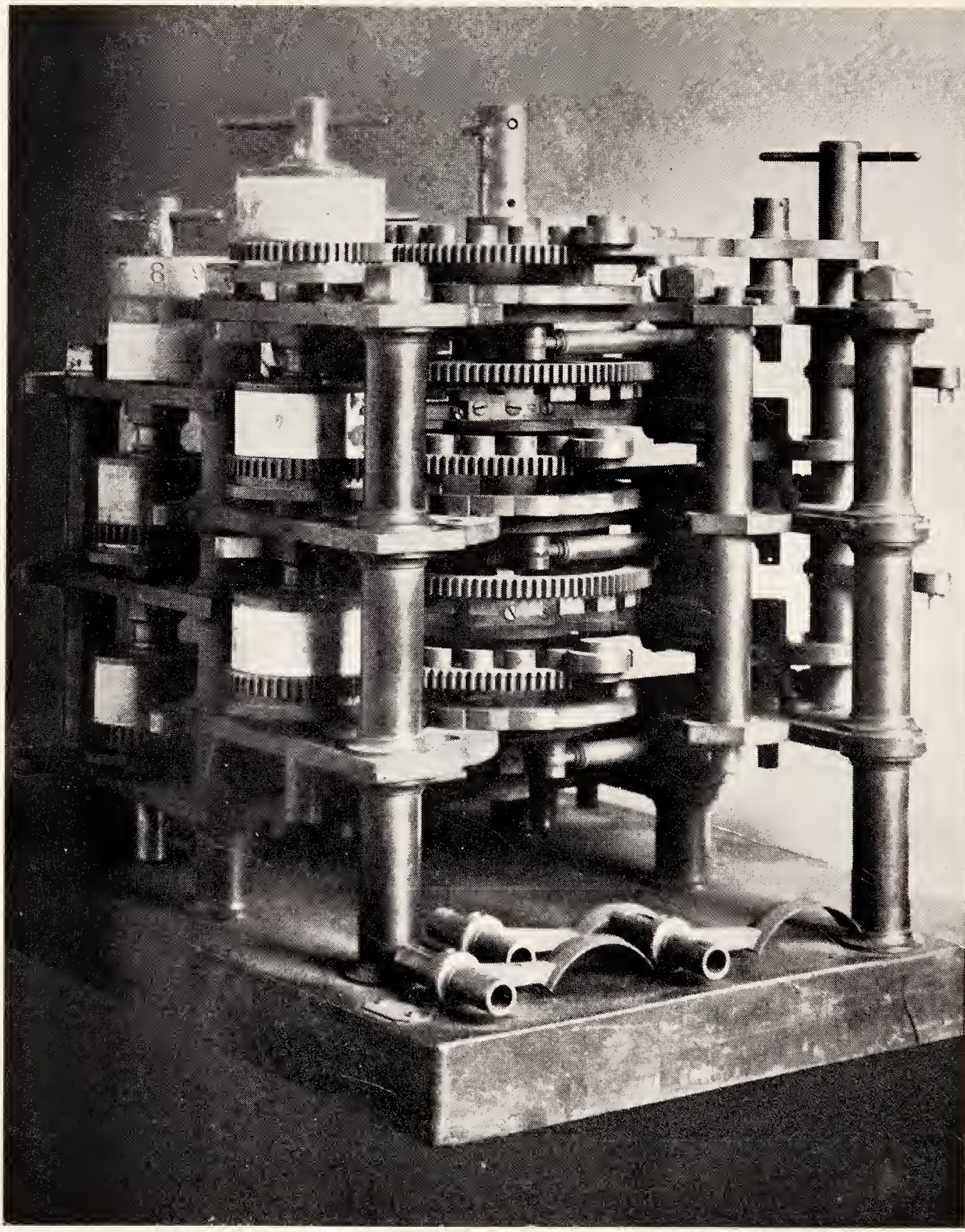
In using the method of 'fluxions', which is identical in its fundamental ideas with what we now call the Differential Calculus, Newton denoted the rate of change of a quantity, say u, depending on another quantity, say t, simply by placing a dot over the u. If u be the length of path travelled over by a point, and t the time, $\dot{u}$ would represent the velocity.

Leibnitz, starting from the idea of infinitely small quantities, placed a d before the symbol of the variable quantity; dt would be an indefinitely small time, and du/dt would represent the velocity. In the sequel, and especially in the inverse process of integration, Leibnitz's notation had advantages which were recognized on the continent, and particularly in France, while Cambridge still employed Newton's notation.

The time was ripe for reform.

The continental method was taught by ROBERT WOODHOUSE (1773–1827) of Caius College, 8th Lucasian Professor of Mathematics between 1820 and 1822, whose *Principles of Analytical Calculations* appeared in 1803, but little attention was paid to him before Charles Babbage (1792–1871), George Peacock, and John Frederick Herschel formed the Analytical Society to reform the teaching of mathematics and advocate 'the principles of pure "*de*-ism" for the "*dot*-age" of the University'.

CHARLES BABBAGE of Trinity, who succeeded THOMAS TURTON and AIRY as the 11th holder of the Lucasian chair, is well known in connexion with the elaborate calculating machine which he designed. He helped to found the British Association in 1830–2. James Forbes of Edinburgh was taken to see the machine on June 5, 1831, 'with Mr.



NO. 87. BABBAGE'S CALCULATING MACHINE

Harris, at the place where the machine is making, near the Bethlehem Hospital, St George's Road. A man of the name of Clement has the entire direction of it, and the mechanism is most splendid: it is almost entirely made by the turning lathe, which he has in high perfection. . . . Mr. Babbage asked me to go and dine with him. I had occasion to see a good deal of his character. . . . It was with the greatest difficulty that I escaped from him at two in the morning after a most delightful evening'.

The Difference Engine was first invented by Babbage in 1812 for the purpose of calculating and printing mathematical tables. It is described in *Babbage's Calculating Engines*, 1889, by H. P. Babbage, and in the *Napier Tercentenary Handbook* 1914.

76. Babbage's Calculating Machine. ?1830–40.

Cavendish Laboratory.

Pres. by C. Babbage 1886.

The instrument figured seems to have been a portion of the Calculating or Difference Engine devised by Babbage and executed between 1823 and 1833 with the aid of a grant of £17,000 from the Government. The greater part of the work was executed by Clement, afterwards associated with Charles Holtzappfel. The imperfection of the whole was undoubtedly due to the unceasing activity of the inventor's mind, which was always foreseeing further possibilities and extensions with which neither the craftsmen nor the financial subventions could keep pace. A large portion, now in the Science Museum at S. Kensington, is said to have been put together in 1833, and further construction to have been abandoned in 1842. It was described by B. Herschel Babbage in a pamphlet issued by the Science and Art Department in 1872, soon after Charles Babbage's death in October of the previous year, with a figure printed by the author in 1853.

The relation of the Cambridge section to the rest, or to the parts in the possession of my friend, Dr. L. H. D. Buxton,[1] is uncertain. The first idea of a calculating machine appears to have come to Babbage at the age of

[1] Cf. Buxton, *Charles Babbage and his Difference Engines, Newcomen Society*, 1935.

21 years, whilst at Cambridge, and he elaborated his ideas in a letter to Sir Humphry Davy, President of the Royal Society in 1822.

Had the engine been completed, it would have been used to calculate and *print* mathematical tables, to 20 places of figures and 6 orders of differences. The operation is explained in Babbage's *Ninth Bridgewater Treatise* and more shortly in B. H. Babbage's tract.

When in 1833 further work was suspended, Babbage commenced drawings for an Analytical Engine.

George Peacock (1791–1858) also of Trinity, collaborated in the new movement, and wrote a report upon the progress of mathematical analysis (1833), for the British Association of which he was an early supporter. He was also a co-founder of the Cambridge Philosophical Society in 1819, and was appointed Lowndean Professor of Astronomy and Geometry in 1836.

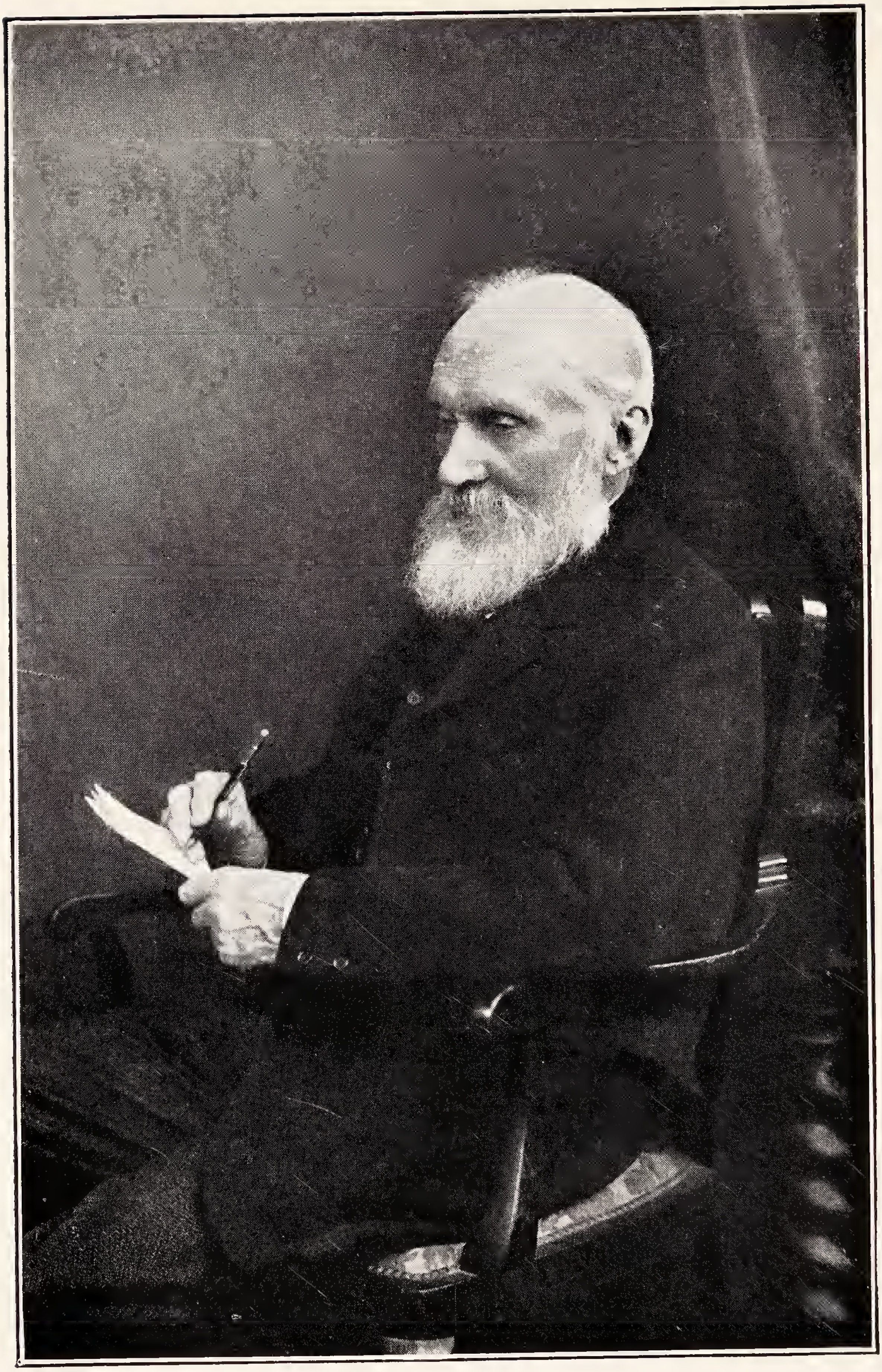
Two other outstanding mathematicians who helped to introduce the differential notation were John F. W. Herschel (1792–1871) of St. John's and William Whewell (1794–1866) of Trinity, the author of the *History of the Inductive Sciences* 1837.

To Babbage succeeded Dr. Joshua King, 1798–1857, who held the Lucasian chair for ten years.

Augustus de Morgan (1806–71), Trinity, 4th wrangler in 1827, was elected to the Professorship of Mathematics at University College in the following year.

His work on the Differential Calculus contains the best exposition of the Calculus. He contributed many articles on the History of Mathematics to the *Athenaeum*, which were reprinted as the *Budget of Paradoxes* 1872, including much on Circle-squaring and on the Trisection of Angles.

We next come to the work of a series of mathematicians who found their inspiration in the problems presented by the various branches of Physics, and especially in those in which a wave theory is involved. And thus new branches of study, such as Physical Optics studied by Airy, mathematical analysis of the problems of Optics, Electricity, Magnetism, Sound rapidly extending, and leading on to developments as unexpected as the appearance of Minerva from the brain of Zeus, have inevitably followed from the



WILLIAM THOMSON, LORD KELVIN

By courtesy of the British Association

analytical methods of members of the new Cambridge Mathematical School.

Between 1840 and 1850 several mathematicians of the highest eminence graduated after passing through the Tripos. William Thomson (1824–1907) in 1845, Peter Guthrie Tait (1831–1901) in 1848. In 1854 the senior wrangler was Edward John Routh (1831–1907)—illustrious as a teacher, the well-known author of *Dynamics of Rigid Bodies*, and the second wrangler was Clerk Maxwell (1831–79). The new teaching was greatly helped by the Board of Mathematical Studies especially constituted 'to encourage attendance at the Lectures of the Mathematical Professors' (Grace of 31 Oct. 1848).

The *Elements of Natural Philosophy*, written jointly by Thomson and Tait, is a monument 'more permanent than bronze'.

James Joseph Sylvester (1814–97), second wrangler in 1837, made his reputation in domains in which few could follow him in higher algebra and the theory of numbers, ending a rather hectic if illustrious career at Oxford as successor to Henry Smith. At Cambridge Arthur Cayley (1821–95) of Trinity was even more revered as Sadleirian Professor. His chief work was *On Elliptic Functions* 1876, and the theory of invariants, and has been collected in thirteen volumes printed at the Cambridge press. George Chrystal published his well-known *Algebra* in 1886.

George Gabriel Stokes (1819–1903) succeeded King in 1849 and was followed after a tenure of 54 years by Sir Joseph Larmor, the 14th holder of the Lucasian chair.

Great names all, but it has been by the application of mathematics to the problems of physics by Lord Kelvin, of astronomy by Airy and Adams, of electricity by Clerk Maxwell, of vibration by J. W. Strutt, Lord Rayleigh, of tides by Sir George Darwin that the popular and international mind has been so powerfully impressed.

Meanwhile graphic methods had been making headway in Germany, mainly owing to the work of August Möbius, a pupil of Gauss, and first director of the observatory at Leipzig. The new ideas were taken up by William Kingdon Clifford, b. 1845, of Trinity, whose *Mathematical*

Papers 1882 and *Common Sense of the Exact Sciences* have had a wide influence in urging the idea of relativity in physical measurements. He died young at Madeira in 1879.

In scholastic circles no name was better known than that of Isaac Todhunter (1820–84) of St. Johns, writer of text-books that raised the standard of mathematical teaching in schools during the second half of the nineteenth century.

Miscellaneous Instruments

77, 78. Napier's Bones in Ivory. c. 1700.

a. In Roger North's Box of Instruments, p. 50.
b. Holden-White Collection, Fitzwilliam Museum.

79. Napier's Bones, Cylindrical pattern. 1720.

Holden-White Collection, Fitzwilliam Museum.

In wooden box, inscribed with *a.* Table of Interest at 5 per cent., *b.* Perpetual Calendar for the years 1720–41, *c.* Tide Table for Ye Chief Ports.

80. Frost's Model of a Magic Cube of Nine. 1877.

St. John's College.

The Construction and Properties of Nasik Squares and Cubes were described by the Rev. A. H. Frost of St. John's College in a paper in the *Quarterly Journal of Pure and Applied Mathematics* in 1877, and he at the same time constructed a glass model of such a cube, which was presented to the South Kensington Museum, and also a Cube of Nine which is in the College Library with the following description:

'This Cube is an extension of the Magic Squares of the Middle Ages, which consisted of numbers arranged in a certain manner in a square, and were used as amulets, or charm for success in love, war, etc.

Viewed from the face which has 242 in the right upper corner, this model contains the consecutive numbers from 1 to 729 (the cube of 9); the middle number of the series is 365, and these three numbers may be seen on the central column of the

NO. 88. FROST'S MAGIC CUBE OF NINE

square on the middle or 5th glass. 27 different square sections of the cube can be taken, viz: 9 on the glasses, 9 from front to back vertically, and 9 horizontally. Each of these squares contains 81 of these 729 numbers, and in any square the sum of the 9 numbers in any row, column or diagonal is the same, viz: 3285, or 9 times 365. This number will also be obtained by adding the 9 numbers in any of the 8 pairs of lines parallel to a diagonal and on opposite sides of it, which together contain 9 numbers, and also the 9 numbers on each of the four diagonals of the cube.

All the pairs of numbers lying on lines through the centra number 365, equidistant from it and on opposite sides of it, have for their sum twice 365 or 730.

This cube of Nine has another curious property, viz: that if in any square section any number be taken, and also the 8 numbers distant 3 places from it in the directions of rows, columns and diagonals, these 9 numbers give the same as all the sets of 9 numbers previously described. For instance, on the outer face of the Cube with 242 in its upper right-hand corner, the numbers 608 and 59, 430, 606, 426, 608, 61, 610, 57 and 428 form such a set of 9 numbers, whose sum is 3285.

These various summations may be tested at a glance (with the exception of the last described) without actual addition, by affixing at the back of each number its equivalent expressed in relation to nines instead of tens; e.g. at the back of 242 we find 288; but here the middle figure 8 is 8 *nines*, instead of 8 tens, and the 2 is twice 81 (9 nines) instead of 2 hundreds. If the Cube be turned round the 729 numbers will be seen in the above altered but equivalent form. In the square now in front, taking, e.g., the column headed 258, and running the eye up its nine numbers, in the place of units will be seen the 9 numbers 1, 2, . . . 9; and in the place of the other two digits the nine numbers 0, 1, 2, . . . 8. This is the case in all the various rows, columns, &c., their order only varying. The sum therefore is the same in each.

81. Mathematical Models.

Cavendish Laboratory.

1. A and B. Models of Wave surface.
   B. Outer cut into to show interior.

2. Models of Wave surface, by W. M. Hicks of St. John's College. See *Messenger of Maths.* 5 (1876), 183–6.
3. Ellipsoid.
4. Ellipsoid.
5. Model of developable surface, discussed by Cayley (Sextic torse). See *Quart. J. Math.* 14 (1877), 229–35. By W. M. Hicks, St. John's College.

6 and 7. Models of Tear dynamic surfaces, by J. C. Maxwell. See *Theory of Tear.*

8. Pseudosphere and flexible surfaces, by J. C. M. in Maxwell case.
9. Hyperboloid of one sheet, deformable, by J. C. M.
10. Cyclide, by J. C. M. See Maxwell, *Quart. J. Math.* 9 (1867), 111–26.

11 and 12. Riemann Surfaces.

13. Cyclide, by Hudson.
14. Cyclide, by T. C. Lewis.
15. Cubic Cone.
16. Cubic Ruled Surface, by R. F. Scott, St. John's.
17. Intersecting Cylinders.
18. Cubic Scroll.
19. Model of Ruled Surface of the 8th degree.
20. Cono-cuneus.

82. Crum Brown's Models of three interlocking surfaces.

Knitted in coloured wools by Professor Crum Brown of Edinburgh c. 1914.

Prof. A. Hutchinson.

83. 'Omega' Calculating Machine.

Archaeological Museum.

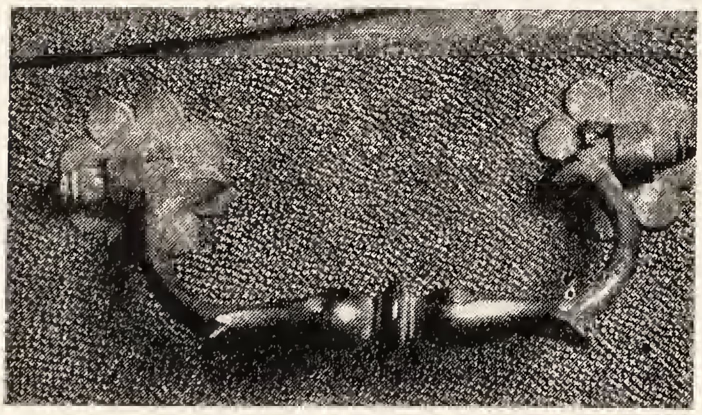
For multiplication and division. 'Patents in all commercial countries app'd for.'

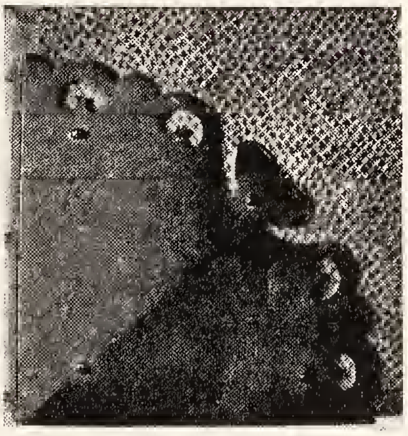
Lucasian Professorship of Mathematics, 1663

1.	Isaac Barrow	1663
2.	Isaac Newton	1669
3.	William Whiston	1703
4.	Nicolas Saunderson	1710
5.	John Colson	1739
6.	Edward Waring	1760
7.	Isaac Milner	1798
8.	Robert Woodhouse	1820
9.	Thomas Turton	1822
10.	George Biddell Airy	1826
11.	Charles Babbage	1828
12.	Joshua King	1839
13.	George Gabriel Stokes	1849
14.	Joseph Larmor	1903
15.	Paul Dirac	1932

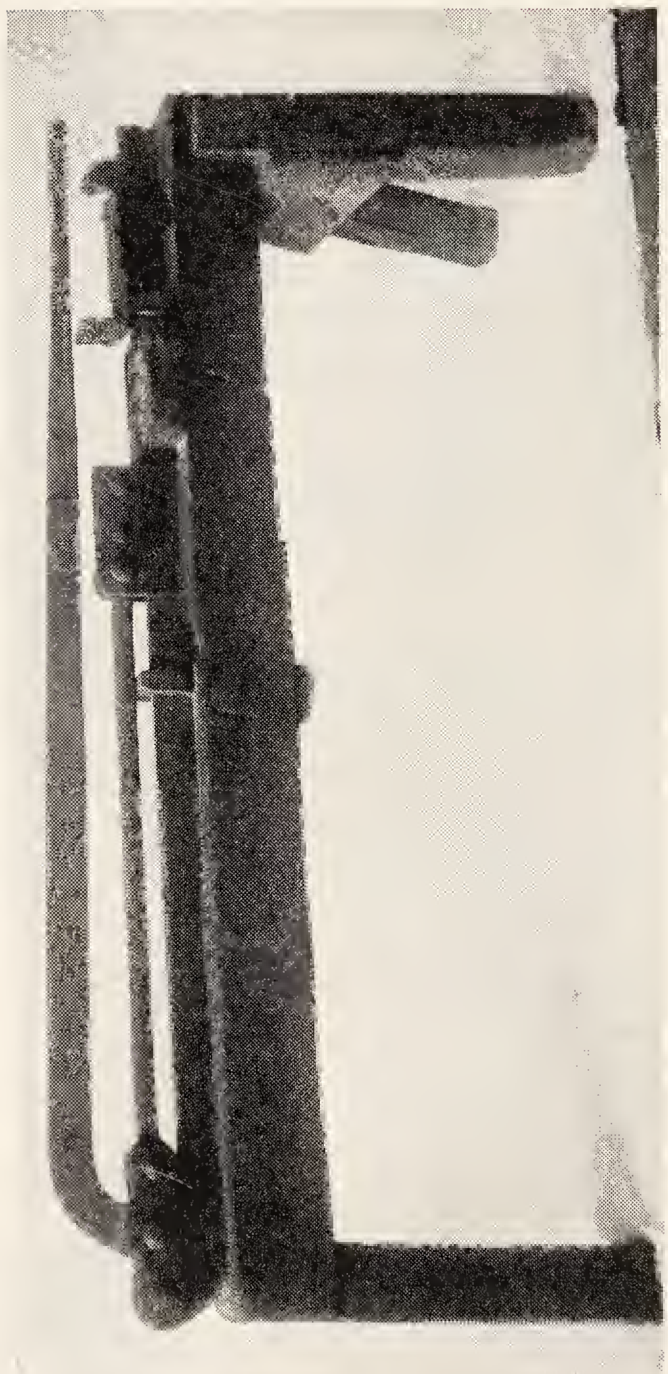
Sadleirian Professorship, 1860

1.	Arthur Caley	1863
2.	Andrew Russell Forsyth	1895
3.	Ernest William Hobson	1910
4.	Godfrey Harold Hardy	1931





Handle and Corner-piece of Roger North's Box of Mathematical Instruments. See p. 49.



W. H. Wollaston's Platinum Press.

IV

MECHANICS AND PHYSICS

The traditional lore of wheelwrights and millwrights naturally far transcends the antiquity of the University and indeed all keeping of records whatsoever. But it is of interest to know that in 1278 there were 3 water-mills, 2 windmills, and 2 horse-mills at Cambridge; and there is even a technical mention of parts of a mill when in 1428 it was laid down that the water-wheel and cog-wheel of the King's Mill with their dependencies are not to be regarded as movables.

The Stocking Loom was invented by a member of Christ's College, William Lee, in 1589, and he practised the art at Bunhill Fields. The invention was discouraged by Elizabeth and James I; but receiving overtures from Henry IV, Lee settled at Rouen.

That there was a real need for better instruction in Natural Science as well as in other subjects was apparent to progressive minds. Sir Thomas Gresham (1519–79), formerly of Gonville Hall, proposed a scheme for utilizing his town mansion in Bishopsgate as a College for higher studies, a scheme which under happier auspices might have given London a University. Soon after his death in 1597 seven Gresham professors were chosen, three from each of the older Universities and one, Henry Briggs, from both. None of the other Cambridge men were scientific.

The inventive faculty was possessed to a remarkable degree by two members of Magdalene College, Sir Samuel Morland and Richard Cumberland. The former had started his career as an ardent politician on the side of the Parliament, and as such had been entrusted by Oliver Cromwell with important diplomatic missions to Geneva, Sweden and Savoy. At the restoration he changed his political views, and becoming a Royalist journeyed to

Holland to meet Charles II, who rewarded him with a knighthood in 1660. At Magdalene he was tutor to Pepys, whom he once admonished for having been seen the night before the worse for drink. His principal experiments were in hydrostatics and hydraulics. He succeeded in making efficient water-engines for raising water from wells and lifting it to high places, such as the top of Windsor Castle, a feat that he found easier than to obtain cash payment from the impecunious Charles. He was however honoured by the title of 'Master of Mechanics' to the King, and by being sent to France to obtain further information as to water-engines. Kindred ideas were involved in his schemes for a fire-engine and for the propulsion of vessels by compressed steam. His other inventions included metal fire-places, for which he, with Thos. Culpeper, obtained a patent, a portable cooker for use when travelling, the speaking trumpet, 'an Instrument of excellent use on Sea and Land', a system of raised writing for the blind, a calculating machine which he dedicated to Charles II in 1666 (an example is contained in the Lewis Evans collection at Oxford), and what especially appealed to the King, a means of opening and resealing correspondence without the risk of detection. Yet Pepys persisted in regarding Morland as a fool, and in sneering at his inventions. He died in 1695, 'the greatest mechanician of the 17th century'.

Richard Cumberland, fellow of Magdalene College, applied the long pendulum to clocks and found out a way of adjusting it by a screw at the top, whereby it may be lengthened or shortened without stopping its motion. He also devised a clock 'for astronomical uses, containing hours, minutes, and seconds, with only three wheels', which passed into the possession of Dr. Stukeley and was 'reckon'd by artists that way a great curiosity'. Cumberland became Bishop of Peterborough in 1691 and died in 1718, aged 86.

After the foundation of the Royal Society, text-books of Physics increased in number and in precision of statement. C. Havers in 1664 provided an English translation of the Discourses of the Virtuosi of France, which was followed twenty years later by Richard Waller's Essays on the Experiments in Natural Philosophy performed at the

Accademia del Cimento (1684). Papin's account of his New Digester appeared in 1681.

H. M. [ ] Cantabrigiensis published in 1671 his résumé of work in Hydrostatics and Optics under the title *Enchiridion Metaphysicae.*

In 1678 the three Laws of Motion were definitely formulated by Newton. They are commonly known as 'Newton's Laws', though the first two are due to Galileo and to Huygens respectively. Galileo's law was that absence of force does not necessarily imply that a body is at rest; it may be moving, but if so, it continues to move in a straight line with unaltered velocity.

Huygens's law allows us to measure a force.

The third or Newton's law states that whenever a body undergoes a change of Motion, there must be an equal and opposite change of motion in another body. This is the law that Action and Reaction are equal and opposite.

In the *Principia,* Newton discusses the changes in the motion of a body acted on by a force directed to a fixed centre. For example, the orbits in which planets revolve round the sun, were defined by Kepler's three laws. What Newton showed in his propositions was that planetary motions may all be accounted for by imagining forces of attraction acting between the sun and the planets to diminish in proportion to the squares of the distances. His theory received its final confirmation by his showing that the intensity of gravitation on the surface of the earth and that acting on the moon were according to the law deduced from the planetary motions; or, that as the distance from the earth to the moon is 60 times the earth's radius, the gravitational force at the surface of the earth is 3,600 times that force which keeps the moon in its orbit.

The studies of a home student at Cambridge of the year 1680, culled from the Hon. Roger North's *Autobiography,* are of interest:

As to study there, I followed my own appetite, which was to Natural Philosophy, which they call Physics, and particularly Descartes, whose works I dare say I read over three times before I understood him. The third time my brains were enlightened, and I gained the notions of his vortices, vapours, and striata. I had this labour for want of a tutor, for my

brother was but so in name for protection, and answering the college, but never read any lectures to me, nor cared to answer my impertinent silly questions, which came upon him so thick that I perceived his temper disturbed at it; for he was a most thoughtful indefatigable man. Therefore I forbore. And at that time new philosophy was a sort of heresy, and my brother cared not to encourage me much in it. I had the old physics, as Magirus[1] and Senectutus[2] but could not thresh so at them. I read most of the latter, but without content; for I was not satisfied to understand that motion was . . . [*sic*] and transparency the act of a clear body, and the rainbow the sun's reflection in a concave cloud, with much of the like nature. I had a book of atomical philosophy, after Democritus, which entertained me better, but I found such a stir about Descartes, some railing at him and forbidding the reading him as if he had impugned the very Gospel. And yet there was a general inclination, especially of the brisk part of the University, to use him, which made me conclude there was somewhat extraordinary in him, which I was resolved to find out, and at length did so, wherein the *nitimur in vetitum* had no small share. I had not been so furiously fond if the author had been obtruded; but shewn and then withdrawn, made us more deviously prosecute him.

After my coming to London I had Dr. Wilkins' Daedalus[3] to peruse. This gave me a full insight into the *theory of mechanical powers*, which I drove as far as I was capa[ble] of doing, resolving not to own any position of natural philosophy which did not quadrate with the general laws of mechanism. And I reviewed all the philosophy I had, and considered it with peculiar regard to them. For I concluded that whatever laws governed body, prevailed throughout, and if any observation seemed to thwart them it was not rightly understood. As for instance that the same body in a swifter motion hath more force, or in other terms, that time is equivalent to quantity in the measure of powers. Whereby it is found that if it can be

[1] Johannes Magirus, *Phisiologiae Peripateticae Libri Sex, cum Commentariis* . . . Cambridge, 1642, 8vo.

[2] Query Sennertus.

[3] Wilkins, *Mathematical Magick: or, the Wonders that may be performed by Mechanical Geometry.* In two Books. The first book is called *Archimedes: or Mechanical Powers.* The second, *Daedalus, or Mechanical Motions.* First published in 1648.

THE HON. ROGER NORTH

contrived that a less quantity shall work in opposition to a greater in an even proportion of celerity, it shall, though of itself the weaker, being so circumstanced, prevail. This appearing to be the measure of all opposed powers, which is the subject of mechanics, I conceived to take place in all cases of collision of body, and so satisfied myself in the reason of the laws of impulses, which have of late, from the hints of M. Descartes, been improved by Mr. Pardies[1] and others to a refined height; and I think I have carried the doctrine farther than they, I mean to cases of all irregular bodies and their unaccountable collisions, shewing that those are governed by as steady laws as the most regular, and by this have explained the windmill, ship sailing to windward, and other exotic forces, clearer than they, for which I must refer to my mechanics.

But while I was a dabbler in mechanics, I fell into that disease that all tyros in that art do, a conceit of having found a *perpetual movement*, and was wonderfully earnest and positive in it, and half wild to be putting it to experiment. This made sport for my brother F. N., who had been sick of the same infirmity, and would undertake, in whatever invention I could propose, to shew me wherein it should fail, and so he let me consider so long as I should. He was such an adept in all ingenious arts, and particularly this of mechanics, that he was master of the demonstration, which I arrived to at last, that such motion was impossible to be made by any mechanism. For if you will move the work continually, it must be done by a rotation or succession of equal powers, which shall take an advantage by the contrivance of the machine to work more on one side than on the other. If they are not equal in power, then the continual equal concern of all in place as they come cannot be maintained, as must be if it be perpetual, which must suppose a rotation. Then, if you will give to an equal a mechanical force above its equal, to weigh it down, it cannot be done but by conveying it farther from the centre of rotation, so as it may move in a greater circle in the same time; and if so, it must fall lower into the perpendicular, which to reduce to the horizon again others must be sent out still farther, and be still lower, and so *ad infinitum*, till the limits of the work puts a stop, and there is an end of the movement. My invention, of

[1] *La Statique, ou la science des forces mondaines.* Par le P. Ignace Gaston Pardies, de la Compagnie de Jésus. Paris, 1673.

which I was so fond, was two wheels on different centres, in the horizontal line, almost contiguous, which should discharge balls out of the one into the other, which, after a demonstration that it is impossible, is needless to explain.

About 1704 STUKELEY and his medical associates saw 'many Philosophical Experiments in Pneumatic Hydrostatic Engines and instruments performed at that time by Mr. Waller, after parson of Grantchester where he dy'd last year being professor of chymistry, & the doctrine of Optics & Telescopes & Microscopes, & some Chymical Experiments, with Mr. Stephen Hales, then fellow of the College, now of the Royal Society'. Both Hales and Stukeley attended Whiston's course on 'Hydrostatics and Pneumatics', at which Robert Boyle's experiments were shown. Further news is obtainable from the letters of WM. RENEW of Jesus College addressed to the Rev. John Strype of Low Leyton, Essex. On January 2, 1706/7, R. says he has become a Junior Soph.

'At which time we begin to study Physicks and Natural Philosophy. I go to lectures to Mr. Grigg (whom I love entirely & who strives in all things to promote my welfare & Learning I'me sure) every morning in Clark's *Physicks*, to Mr. Townsend in ye afternoon in Rohault's *Physicks*; and I am not a little taken with ye study of naturall Philosophy.'

In 1707 the duty of showing a course of philosophical experiments was undertaken by Professor Whiston in conjunction with Roger Cotes, who lectured on Hydrostatics and Pneumatics. Practical work by students was as yet non-existent. It is not generally realized that the teaching of Natural Science by the experimental method is only of recent origin in the Universities. It is probably true that those who gave instruction in medical subjects, or chemistry, or astronomy did not fail to point out the practical application of their discourse, but that falls far short of real practical work by the students themselves in a laboratory.

In 1708 we find Renew keeping an act in the Schools upon the Questions 'Philosophia naturalis non tendit in atheismum'. 'Materia non potest cogitare.' 'Materia est divisibilis in infinitum.'

'I was baited 2 or 3 hours by 3 opponents and then came down without much disgrace. . . . I have a peice of very ill news to send you i.e. viz. yt one *Whiston* our Mathematicall Professor, a very learned (and as we thought pious) man has written a Book concerning ye Trinity & designs to print it, wherein he sides with ye Arrians; he has showed it to severall of his friends, who tell him it is a damnable, heretical Book, & that if he prints it, he'll lose his Professorship. . . .'

Much interest was being taken in new machines at this time. Jackson, a London mechanician, had 'all manner of curious inventions to his credit, such as a coach that cannot be overturned; a special kind of casts of limbs for painters and sculptors etc.'. When Uffenbach tried to find him on 29 October 1710, he was not in London but at Cambridge.

The practical application of machinery, however, left something to be desired, for instance when on 30 September, 1731, a great fire broke out at Barnwell and consumed fifty houses, 'the fierceness was so great that it destroyed even the fire-engine'.

On May 2, 1735, Dr. Samuel Dale saw 'Hawksby's Pneumatick Engin' in Mr. Davis's chamber in Queens' College, and two years later 'a double barrelled Pneumatick machine' in the Observatory over the Great Gatehouse of Trinity.

The Bridge at Queens' was wholly rebuilt in 1746. 'Without flattery it may be esteemed one of the most curious pieces of Carpentery of this kind in England. It contains in length upwards of 50 foot, being of one arch, composed of timber curiously joined together, and supported on abutments of Rustic Stone-work between which is a passage for the Cam 40 foot in the clear, and of such height that the waters in a common Flood cannot reach the lowest timbers thereof. The Master's Lodge in 1752 was furnished with Musical and Mathematical Instruments; and in a Ground Room 'he hath a Printing Press with the Apparatus belonging thereto, wherein he is Printing his Astronomical Works.'

A good deal of lathe-work is said to have been done about 1750 by Dr. Charles Mason (B.A. 1722), the Professor of Geology and one of the senior fellows of Trinity,

who was a good practical mechanic. (Cumberland's *Memoirs*, p. 106.)

A Deep-Sea Bucket with two connected valves for bringing up sea-water from great depths was the invention of STEPHEN HALES. It was used by Capt. Henry Ellis in 1749 for bringing up water with a thermometer immersed therein from a depth of 891 fathoms. *Phil. Trans.* 1751.

Hales's other machine, a Sea-gauge to measure 'the Unfathomable Depths of the Sea with great Expedition and Certainty', was not very practical, and was not repeated. It consisted of a hollow copper sphere attached to a long metal tube with a central metal rod. Carried down by a sinker until it struck the bottom, it released the sphere, allowing it to float up to the surface.

As pressure rose, water, on which 'tingid unctuous matter' floated, was squeezed into the sphere, and when it decreased the unctuous matter left a mark on the central rod, from this the amount of compression could be calculated, which in turn would give the depth. *Gent. Mag.* 1754, xxiv. 215; *Phil. Trans.*, xxxv. 559. Hales also experimented on methods for cleaning harbours.

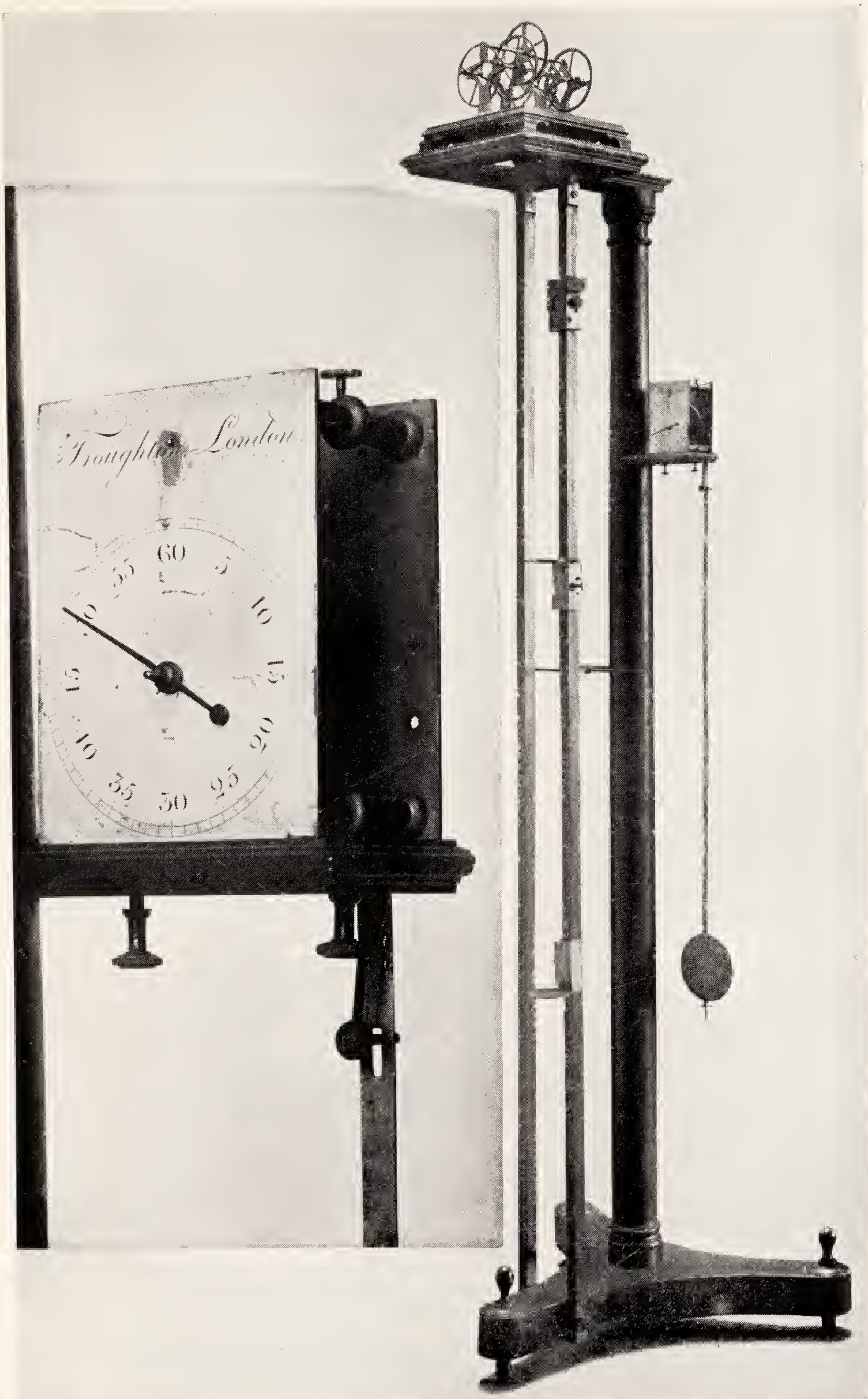
The paletts of the public clock at Trinity College were set out by Mr. John Harrison, c. 1755, in the face of the leading palett being a plane and the face of the other palett concave. (W. Ludlam, *Astronomical Observations*, 1769, p. 135.)

In 1776 a Course of Lectures on Experimental Philosophy was given at Trinity College by the Plumian Professor, ANTONY SHEPHERD of Christ's, who in 1768 had been appointed Master of Mechanics to his Majesty. He was described by Fanny Burney as 'prodigiously tall and stout' and as 'dullness itself'.

An important research was being carried out about 1780 by GEORGE ATWOOD (1746–1807), fellow of Trinity, F.R.S., an account of which appeared under the title *Treatise on the Rectilinear Motion and Rotation of Bodies with Description of original Experiments on the Subject* with 8 folding plates by Basire. Cambridge 1784.

This was the first description of 'Atwood's Machine' for verifying the accelerative action of gravity.

The importance of the various branches of Natural Philosophy was becoming more and more felt, perhaps by



EARLY ATWOOD'S MACHINE AND CLOCK BY TROUGHTON

By the courtesy of Prof. H. S. Allen of St. Andrews

no one more than by the Rev. Richard Jackson, M.A., fellow of Trinity 1730, who died in 1782, making provision for founding and endowing a special Professorship of Natural and Experimental Philosophy.

Isaac Milner, president of Queens' College, was appointed first Jacksonian Professor in 1783 (see p. 230).

In accordance with the will of the founder, an abundance of 'facts' in Natural Philosophy were demonstrated. But it may have been a case of quantity rather than quality, for his experiments in Optics were said to have been 'very little more than exhibitions of the Magic Lanthorn on a gigantic scale and the guinea and feather experiment had always a somewhat uncertain ending'. (Gunning, *Reminiscences*, I, p. 236. His chemical lectures were better.

On the resignation of Milner on March 12, 1792 there was an election, in which Francis John Hyde Wollaston (1762–1828), fellow of Trinity Hall, beat William Farish, fellow of Magdalene College, by 35 votes to 30. Mr. Farish was elected Jacksonian Professor in 1813.

Wollaston at first fulfilled the conditions of the chair, but when in 1796 Vince was elected to the Plumian professorship, and lectured on Experimental Philosophy, Wollaston devoted himself to Chemistry alone (see p. 232), his philosophical apparatus being handed over to Vince. He gave lectures alternately on chemistry and experimental philosophy which are said to have been illustrated with not less than three hundred experiments annually (*Cambridge Calendar*, 1802, p. 32). In 1807 Wollaston became Master of Sidney Sussex. His contributions to learning included a *Description of a Thermometrical Barometer for measuring Altitudes*, *Phil. Trans.* 1817, and *On the Measurement of Snowdon by the Thermometrical Barometer*, *Phil. Trans.* 1820.

Francis Wollaston was the brother of Dr. William Hyde Wollaston, senior fellow of Caius College, who invented the Goniometer for measuring the angles of crystals, and patented the Camera Lucida in 1807. It was a time when the skill of English instrument-makers of excellent physical apparatus was famed all over the continent. The extensive outfit deemed necessary for a scientific explorer in 1791 is

on record. William Gooch of Caius was collecting scientific instruments for a voyage of investigation to assign Bounds to the English Territories in South America. He never returned, having been murdered by natives on 13 May, 1792 on the island of Woahoo, Sandwich Islands. The instruments were 'most of them the same that went with Captain Cooke'.

1. An Astronomical Clock.
2. A Journeyman Clock.
3. An Alarm Clock.
4. A good Watch with Second Hand.
5. An Achromatic Telescope of 46 in. focus with a divided object glass Micrometer.
6. A Reflecting Telescope.
7. A Verticle Circle with an Azimuth-Circle for taking altitudes and azimuths.
8. A Transit Instrument of 4 feet with a level and upright wooden posts.
9. A Marine Dipping needle.
10. A small Pocket Compass.
11. A set of Magnetic Bars to charge the poles of the Dipping Needle.
12. A Burton's Theodolite with stand.
13. A Hadley's Sextant by Dollond.
14. Another by Troughton.
15. Two large Thermometers.
16. Two Thermometers with wooden scales by Ramsden.
17. A portable Barometer by Burton.
18. A Bason to hold Quicksilver with Glass roof.
19. Quicksilver in a Bottle.
20. A Night Telescope.
21. A Steel Gunter's Chain.
22. A Knight Azimuth Compass by Adams.
23. A Portable Tent Observatory.

The list of books that Gooch took on board the *Daedalus* is also contained in the inventory of his outfit. He seems to have been one of the very first of many eminent Scientific Travellers sent out from Cambridge, for he was appointed by the Board of Longitude, among the members of which were J. Smith, master of Caius, E. Waring (Magd.), Dr. A. Shepherd, F.R.S., Plumian Professor and Master of Mechanics to the King.

Some advertisements which have survived show that in the Michaelmas term of 1793 regular and apparently coordinated courses of instruction were being given in scien-

tific subjects, with a view to helping candidates for the degree of B.A., both in the university and in some of the colleges. Thus Vince put forth such a sheet three years before he was elected to the Plumian Professorship.

I. Cambridge, Oct. 10 1793.

On Monday, Nov. 18 at *four* o'clock in the Afternoon

The Rev. S. Vince A.M., F.R.S.,

Proposes to begin his *Philosophical Course* of Public Lectures on the *Principles* of the *Four Branches of Natural Philosophy,* With the Application to a great Variety of *Problems* of Sir I. Newton, with the most useful *deductions.*

To be continued every Monday, Wednesday and Friday.

That Part of the Course which contains the Lectures on the *Principia,* will for the Conveniency of those who shall then have commenced Sophs, be given at the End of the present and Beginning of the next Term.

And on Tuesday Nov. 19 at the same Hour, he proposes to begin his *Mathematical Course* of Public Lectures on the Principles of *Arithmetic, Algebra, Fluxions, Trigonometry, plain* & *spherical, Logarithms, Ratios* &c. &c.

To be continued every Tuesday, Thursday & Saturday. Each course to be attended a second Time gratis.

Terms of attendance are 5 Guineas for each Course. They who purpose to attend are requested to send in their Names.

II. Trinity Hall, Nov. 2, 1793.

Rev. F. Wrangham, with the Assistance of Basil Montagu M.A. (Chr.) will deliver (at 4 p.m.) a Course of Lectures upon

Mathematics and *Natural Philosophy.* The Mathematical part will include *Algebra, Fluxions* &c. The Philosophical Part the *Four Branches, Newton's Principia* &c. Illustrated by a Variety of Problems. Terms of attendance 5 Guineas each Part; or 8 Guineas the whole course.

III. The Jacksonian Professor (F. J. H. Wollaston) lectured on the same subjects and advertised his willingness to 'instruct questionists' in the ensuing January.

IV. Professor Busick Harwood similarly advertised his lectures on Human Anatomy and Physiology.

And on the other side, Wordsworth has printed the private diary of a Trinity Undergraduate for the same period stating that in November 1793 he was reading 'Ratios and Variable Quantities', transcribing a Syllabus of Mechanics, and being taught Astronomy and Spherical Trigonometry by Mr. Tavel in Trinity, and attending Prof. Wollaston's lectures in addition to his Classical classes. Wordsworth, *Univ. Life*, 589–91.

The huge subject of Natural Philosophy was beginning to grow beyond the powers of one man, and specialization began even before the beginning of the 19th century. Notes on the separate branches of Physics may therefore be conveniently grouped under the heads to which they refer.

Weighing the Earth

The Rev. John Michell (1724–93) of Queens' College had constructed an apparatus for determining the average density of the earth by measuring the attraction between two spheres of lead. At his death the apparatus passed to Francis J. Hyde Wollaston, the Jacksonian Professor, who wisely handed it over to Henry Cavendish, who carried out the experiment in 1798.

A torsion balance was constructed with a metal rod about 2 yards long, suspended by a torsion wire, and carrying at each of its ends a leaden sphere 2 inches in diameter. This was started oscillating slightly, while two larger 8 in. spheres could be brought near the smaller spheres, and by exercising a gravitational pull upon them, would effect a change in the centre of oscillation. By reversing positions the centre of oscillation could be displaced in the opposite direction. After elimination of all suspected errors, Cavendish arrived at the wonderful result of 5·48 for the mean density of the Earth. By his kinsman he was described as 'the man who weighed the world, and buried his science and wealth in solitude and insignificance at Clapham'.

Nevile Maskelyne (1732–1811) of Trinity, Astronomer Royal for forty-six years, designed and carried out his well-known experiment to ascertain the density of the earth. For this it was necessary to measure the force with which two known masses attract one another. From such a

measurement he calculated the total weight of the earth, and then from its known dimension, its mean density. With the assistance of CHARLES HUTTON (1737–1823), Professor of Mathematics at the Royal Military Academy at Woolwich, Maskelyne chose two stations, one to the north and the other to the south of the mountain Schiehallion in Perthshire. He then determined their latitudes astronomically, and measured the distance between them. The discrepancy between the observed and the measured distances gave the data necessary for calculating the gravitational pull of the mountain upon the plumbobs used to indicate the 'vertical'.

The results obtained by Maskelyne and Hutton gave the density of the earth as 4·48 to 5·38 times heavier than that of water.

Yet another attempt was made in 1826 when in conjunction with Whewell, Airy endeavoured to measure the Density of the Earth by comparing the vibration-times of a pendulum at the surface of the earth and at 1,200 feet below the surface. An 'underground chamber', in Dolcoath Mine, at Camborne, was chosen as the rendezvous for the experiment:

> 'The stillness of this subterranean solitude', wrote Whewell to Lady Malcolm, 'is interrupted by the noise, most strange to its walls, of the ticking of my clock, and the chirping of seven watches. . . . I have sat here for some hours, and shall sit five or six more, at the end of which time I shall climb up to the light of the sky in which you live, by about sixty ladders.'

Meanwhile the needs of students had been partially met by JAMES WOOD (1760–1839), F.R.S., the 31st Master of St. John's College (1815), who had published useful textbooks on *The Principles of Mechanics* in 1796 and on *The Elements of Optics* 1798. His enthusiasm for this subject led him to call his favourite riding-horse *Mechanics*, so that 'Wood on Mechanics' was for a time a topical jest among the undergraduates.

The master minds were also active.

GEORGE CAYLEY made the earliest recorded experiment in free flight with an 'aeroplane' or gliding machine having both vertical and horizontal 'rudders'. A reproduction of

Cayley's First Model Glider, 1804, in the Science Museum is based upon a sketch and description contained in Sir George Cayley's Notebook (c. 1799–1826).

The essential description of the device is as follows:

'A common paper kite containing 154 square inches was fastened to a rod of wood at the hinder end and supported from the fore part from the same rod by a peg, so as to make an angle of 6°. With it this rod proceeded on behind the kite and supported a tail, made of two planes crossing each other at right angles, containing 20 inches each. This tail could be set to any angle with the stick. The ratio about 5 square feet of surface to the pound—velocity 10 miles per hour.' *The Aeronautical Journal*, June, 1933.

W. Hyde Wollaston also made some notable contributions to the subjects of *Percussion* in 1816; *On a Method of Drawing extremely fine Wires, Phil. Trans.* 1813; and *On the finite extent of the Atmosphere, Phil. Trans.* 1822.

The invention of an internal combustion engine has been ascribed to the Rev. William Cecil, fellow of Magdalene, who in 1820 brought an account of it before the Cambridge Philosophical Society, and published in 1822 '*On the Application of Hydrogen Gas to produce a moving power in machinery with a Description of an Engine which is moved by the pressure of the Atmosphere upon a Vacuum caused by explosions of Hydrogen Gas and Atmospheric Air.*' In the engine that was exhibited at a meeting of the Philosophical Society a 'stream of pure hydrogen is mixed with air in the proportion of two to five and passes along a tube to the machine itself; a small valve in it is alternately opened and closed by a connection from the piston, so that a fixed quantity of the mixed gas is admitted at every stroke.

'The valve being closed, the mixture passes into a receptacle provided with a touch-hole, at which a flame is burning, but which is only temporarily opened by another connection with the piston as it returns to its cylinder. This ignites the gas, and the force of the explosion drives out the piston from the cylinder . . . it made 60 revolutions a minute, and consumed about 17½ cubic feet of hydrogen in an hour; but, of course, hydrogen is not cheap, and this

would probably be the reason that Cecil never tried to bring his model into practical and commercial use.

'He suggested that "coal gas, vapour of oil, turpentine, or any ardent spirit" might be substituted for it, but he does not seem to have tried them, or gas engines and motors might have been anticipated by many years. Except for the fact that an electric spark is now used to ignite the explosive mixture, being more convenient than a flame at a touch-hole, it is difficult to see how Cecil's engine differs from the internal combustion engines in use at the present day.' (Stephen Gaselee in the Magdalene College Magazine 1911.)

In May 1831 a short but very fruitful visit to Cambridge was paid by James D. Forbes, who describes it as one of the happiest weeks in his life in the society of Whewell, Sedgwick, Airy, and Peacock. The physicists were young then—Whewell 37, Airy only 30. He considered Airy's lecture on mechanics a 'beautiful extempore explanation of the three axes of rotation and the cause of precession'. When two years later Forbes became professor of Natural Philosophy at Edinburgh, he consulted Whewell on many points in Natural Philosophy and Mechanics, and asked for advice on various points, especially in regard to text-books, for he felt that the text-books used at Cambridge would be useless for his class at Edinburgh, owing to the then 'low state of mathematical knowledge among Scottish students'.

Thus was the influence of Cambridge teaching spread far afield.

In 1854 Cayley returned to his early love of flying and made an 'Improved Chinese Flying Top' to illustrate the principle of the lifting airscrew, for experiments in regard to mechanical flight.

It consists of three thin metal vanes set (in this case), at an angle of about 25° to the plane of rotation and mounted on a vertical spindle which rests freely in a wooden holder. The upper part of the front or leading portion of each vane is cut away in order to obtain a fine entering edge—a significant feature of this model airscrew. The method of operation was to rotate the spindle rapidly in the holder by means of a cord wound round it, when the airscrew would rise to a considerable

height, thus demonstrating the principle of the helicopter.

A reproduction of Cayley's instrument was exhibited at the Royal Society's conversazione in 1934.

The study of Applied Mechanics was greatly advanced by the appointment of Robert Willis, F.R.S., who was already known as a competent architect, to the Jacksonian Chair in 1837. He was the inventor of the odontograph and cymagraph, and some of his models are still preserved in the Engineering Laboratory (p. 500).

Clerk Maxwell (1831–79), Trinity 1860, Professor at King's College, London, 1871, led the simplest of lives. 'I have regularly set up shop now above the wash-house at the gate, in a garret. I have an old door set on two barrels, and two chairs, of which one is safe, and a skylight above, which will slide up and down.' Such was Clerk Maxwell's own description of his workroom in 1848. Starting in such a crude and unpromising environment he became convinced that many of the greatest problems in physics can be solved with comparatively simple apparatus.

Space will not permit even to attempt to give due proportion to the work of Clerk Maxwell. Suffice it to say that he will be remembered as one of the greatest of the modern school. His work on Electricity and Light will be mentioned later. Here it is fitting to mention his brilliant essay on the dynamical conditions of stability of the ring system of Saturn, his investigations on the kinetic theory of gases, his *Discourse on Molecules*, and his suggestive little book on *Matter and Motion*.

The establishment of the **Cavendish Laboratory** of Experimental Physics in 1873 marked the beginning of an epoch in Cambridge, and a certain glamour will always attach to the first students who worked in it with Clerk Maxwell as first Cambridge Professor of Experimental Physics. The Lecture Room was of Maxwell's own designing and the cost of the whole building was defrayed by the Duke of Devonshire.

Among others who came up expressly to study under Maxwell was Ambrose Fleming (1849), who acted as demonstrator to Prof. James Stuart before he went on to Nottingham and to University College in London.

The highly important properties of Vortex Rings were investigated by Sir J. J. Thomson, and by W. Mitchinson Hicks of St. John's, whose papers on Toroidal Functions (1881–5) and on the steady motions of a hollow vortex have led to a possible vortex theory of the chemical atom, in accordance with the original suggestion of Lord Kelvin's that such rings in a perfect fluid possess the characteristic property of matter—viz. indestructibility.

Of Sir Charles Parsons it has truly been said that his genius as an engineer has opened up a new era in the production and application of Power. He was born in 1854, the youngest of six sons of the 3rd Earl of Rosse, P.R.S., 1848–54, at whose family-seat at Birr Castle he had the best of all education—a full life in the workshops, forge, foundry, chemical laboratory, and astronomical observatory. His tutor was no less a personage than Sir Robert Ball. In 1872, when Arnulph Mallock came to Oxford, Charles Parsons went up to St. John's College, and became the pupil of Routh. He graduated as 11th wrangler in the year 1877 when Sir Donald MacAlister was senior wrangler. He then went as a pupil-apprentice into the Armstrong works, where he worked out the epicycloidal engine he had modelled at Cambridge. From 1884–9 he was in partnership with Clarke, Chapman & Co. of Gateshead, and in April 23 took out his first patent for the Steam Turbine, the success of which lay in the division of the whole expansion of the steam into a number of separate successive stages, at each of which sets of moving oblique vanes are arranged so as to take up the energy. In 1897 it was applied to the *Turbinia*.

His distinguished optical work is noted on p. 108. In 1888 he tried to make diamonds. He was elected F.R.S. in 1898.

'Besides being by far the greatest and most original engineer this country has had since the time of Watt, he was one of the kindest and most steadfast of friends, and his death has made in the lives of many a gap which will not be filled.'

(Sir Jos. Thomson in *The Times*, Feb. 16, 1931.)

Professorship of Mechanism and Applied Mechanics

The need of a professorship of Mechanism and Applied Mechanics began to be felt about 1875, when Sir James Dewar was invited to fill the Jacksonian chair of 'Natural Experimental Philosophy and Chymistry'. So James Stuart was appointed to lecture on the principles of mechanism, the theory of machines including the steam-engine, the theory of structures. There was no laboratory, until a shed was put up to hold workshop appliances collected by the professor, whose office was moreover to 'terminate with the tenure of the office of the professor elected'. After a decade of trial the educational value of workshops was debated, and in 1890, on Stuart's resignation, a syndicate was granted further powers to enquire whether it be desirable to develop further the Engineering School in Cambridge. At this juncture J. Alfred Ewing of Edinburgh was appointed professor. On Nov. 10, 1892, the Mechanical Sciences Tripos was established, the first examination being held in 1895. Now the Engineering Tripos list is among the largest in the University. His laboratory soon grew by the generosity of donors, particularly from the John Hopkinson memorial gift in 1899.

In 1903 Ewing resigned to take service as Director of Naval Education to the Admiralty, one of the most responsible posts in the Empire. During the War he was head of the secret department known as 'Room 40', for dealing with enemy cipher, even as Charles II's master of mechanics had been long years before. In 1916 at the age of 62, he began a new life as principal and vice-chancellor of the University of Edinburgh. Such is the briefest epitome of the life of the man who founded the Engineering School at Cambridge.

Certain of the older instruments in the department are mentioned on page 500.

Professors of Engineering.

1.	James Stuart	1875
2.	Sir J. Alfred Ewing, K.C.B., King's	1890
3.	Bertram Hopkinson, F.R.S., Trinity	1903
4.	Charles Inglis, King's	1919

ROSE ENGINE-TURNING IN IVORY

NO. 97. PEDOMETER

NO. 86. MAXWELL'S WIRE METER

86. Instrument for measuring the total length of wire on a coil, designed by Clerk Maxwell.

By *Elliott Bros. London.*

The wheel ran on the coil as it was wound in the lathe.

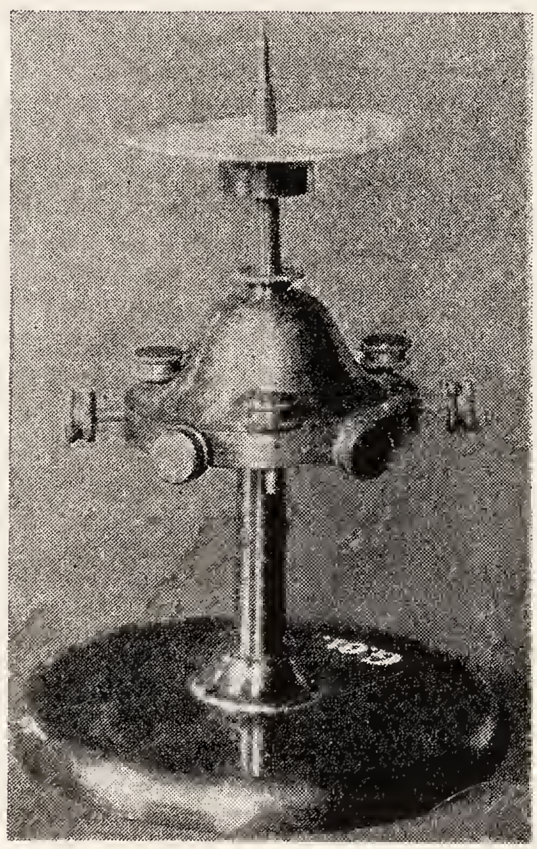
87. Weldon's Screw Micrometer. c. 1888.

Zoological Laboratory.

Designed by W. F. R. Weldon, circa 1888. Wheel graduated 0 to 50. Screw $6\frac{1}{2}$ inches long. By 'J. H. Steward, 406 Strand, London.'

88, 89. Clerk Maxwell's Dynamical Tops. 1855–6.

Cavendish Laboratory.



For illustrating the properties of Moments of Inertia. When balanced on its centre of gravity the top moves as a body under no forces. The earlier model is made of wood.

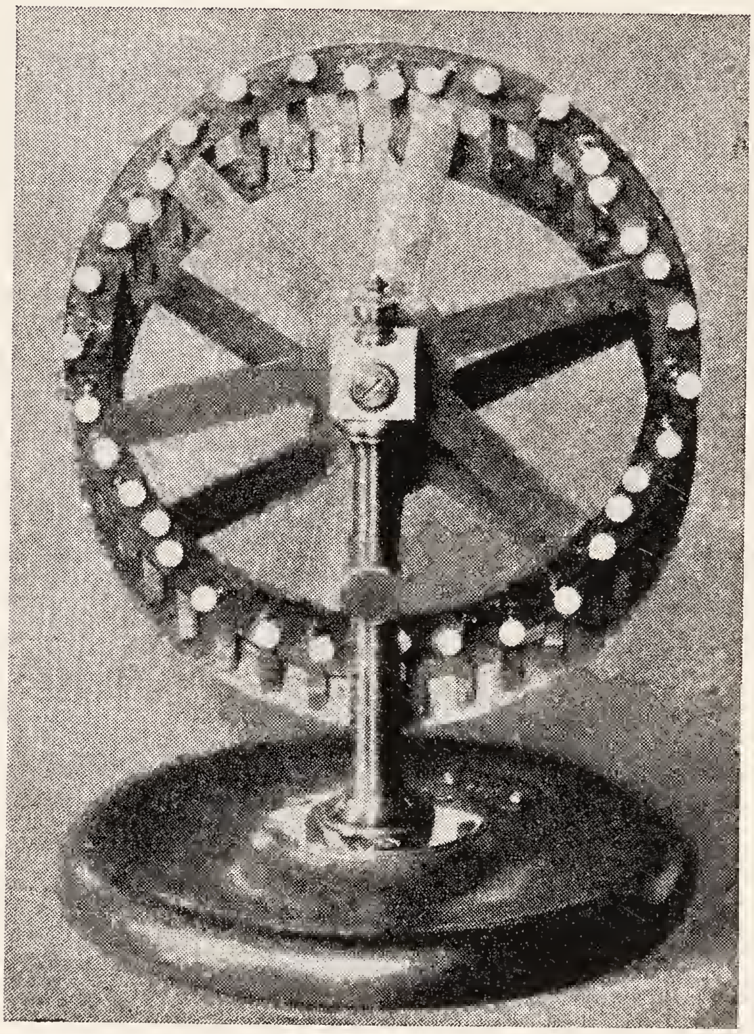
The later model was made of brass by Ramage of Aberdeen and exhibited by Maxwell at a Cambridge tea-party in 1857. The axis of rotation was indicated by a colour-disc fixed upon and spinning with the top.

Royal Soc. Edinb. xxi.

Maxwell's 'Spinning Wheel' or Diabolo was an outcome of the Dynamical Top.

90. Maxwell's Model to illustrate motion of Saturn's Rings. 1857.

Cavendish Laboratory.



Maxwell's solution of the problem of 'The Stability of Saturn's Rings' set as the subject for the Adams Prize Essay of 1857. He described the model as 'two wheels turning on parallel parts of a cranked axle; 36 little cranks of same length between corresponding points of the circumference; each carries a little ivory satellite'.

91–3. Long case Clocks.

On loan to Fitzwilliam Museum.

By 'Edwardus East, Londini'. c. 1690.
'Ioseph Knibb, London'. c. 1695.
'Tho. Tompion'. c. 1700.

94. Bracket Clock. c. 1700.

Fitzwilliam Museum.

By 'Tho. Tompion, Londini Fecit'.

95. Astronomical Clocks. 1767.

a. By 'John Shelton, London'. St. John's College Observatory.

b. By 'T. Jones'. Pembroke College.

At the Hartwell Observatory in the time of Admiral W. H. Smyth.

96. Collection of Watches.

Fitzwilliam Museum.

The university collection of watches is exhibited with a view to displaying their highly ornamented cases rather than the essential details of mechanism upon which the perfection of the instrument depends.

The series includes a number of 16th-century examples in Rock-crystal cases of South-German make, including one by *Klotz* of Augsburg.

Jean Gallier, 16th Cent., *Bobinet, c.* 1630, *Paul Dufour,* 1740, figure among the French makers. The English examples include a fine example of the work of *Geo. Margetts* of London.

97. Pedometer Watch. c. 1800.

Fitzwilliam Museum.

By RALPH GOUT LONDON.

With long handle pivoted to handle of instrument. The watch face is marked with four dials showing (*a*) Time, (*b*) Paces up to 100, (*c*) 100s, (*d*) 1,000s of paces.

Gout patented his invention, No. 2351, in 1799.

98. Pedometers. c. 1810.

Fitzwilliam Museum.

By 'Spencer & Perkins, London'.

Another example is in the Archaeological Museum.

99. Barometer. ?1767.

St. John's College.

By 'Bennett, London'.

100. Mountain Barometers. c. 1841.

Dept. of Mineralogy.

Used by Prof. Miller when determining the densities of standard pound weights.

101. Large Cuthbertson Air-pump. c. 1790-1800.

Queens' College.

By 'R[ichard] Saunders, Salisbury Court, London'.

102. Series of Pumps in the Cavendish Laboratory. **1. Hawksbee type. 2. Ladd. 3. Tate. 4. Tait: single barrel. 5. Fleuss. 6. Gaede Mercurial. 7. Hyvac. 8. Toepler. 9. Modern Gaede Diffusion pump.**

103. Hydrometers.

Cavendish Laboratory.

Set of five in box, by *Will. Twaddell, Spirit Proof Maker, No. 84 Saltmarket, Glasgow.*

104. Hydrometer. No. 10198.

Cavendish Laboratory.

By *Dring & Fage.*

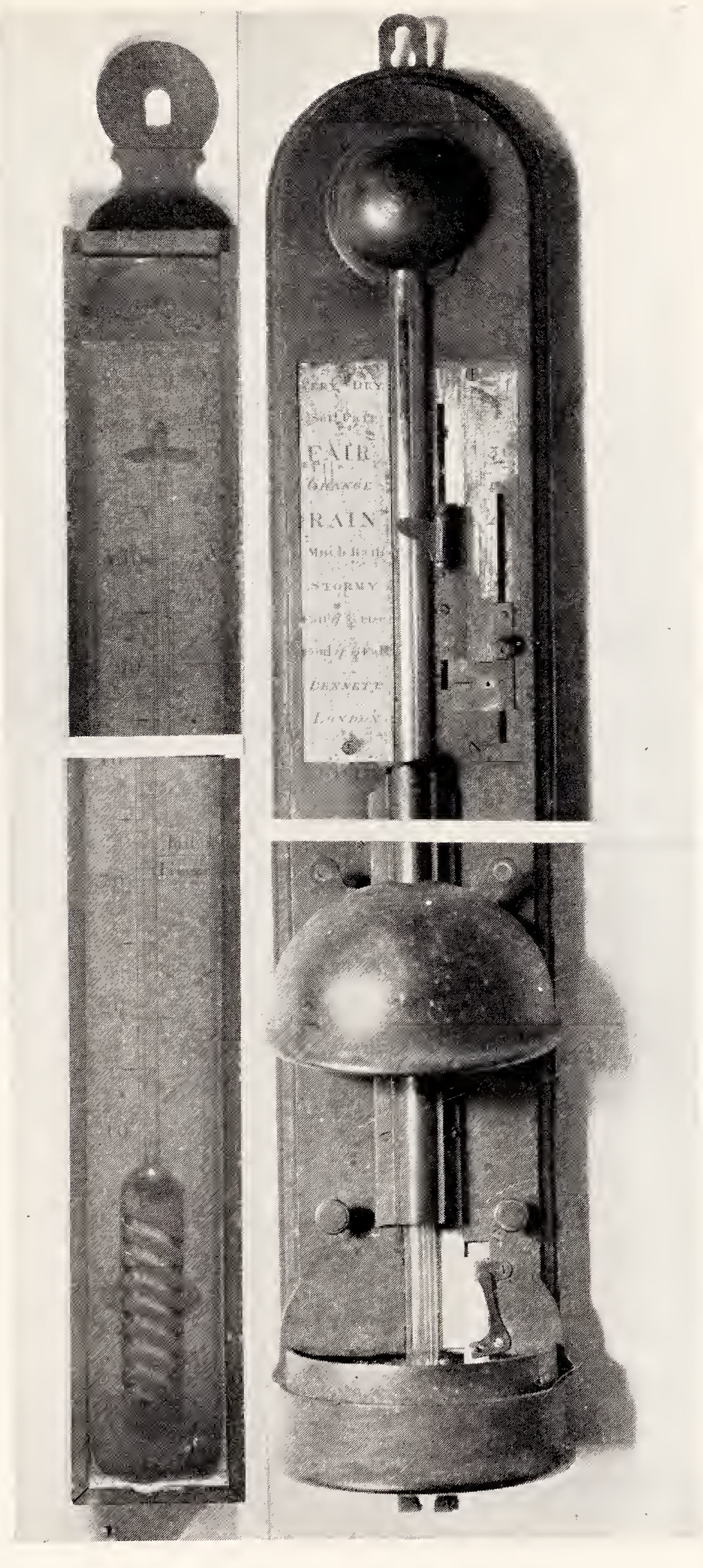
105. Sikes's Hydrometer. No. 3006.

Cavendish Laboratory.

By *Bate, Poultry, London.* Maker for the Revenue of the United Kingdom.

106. Argent[omete]r.

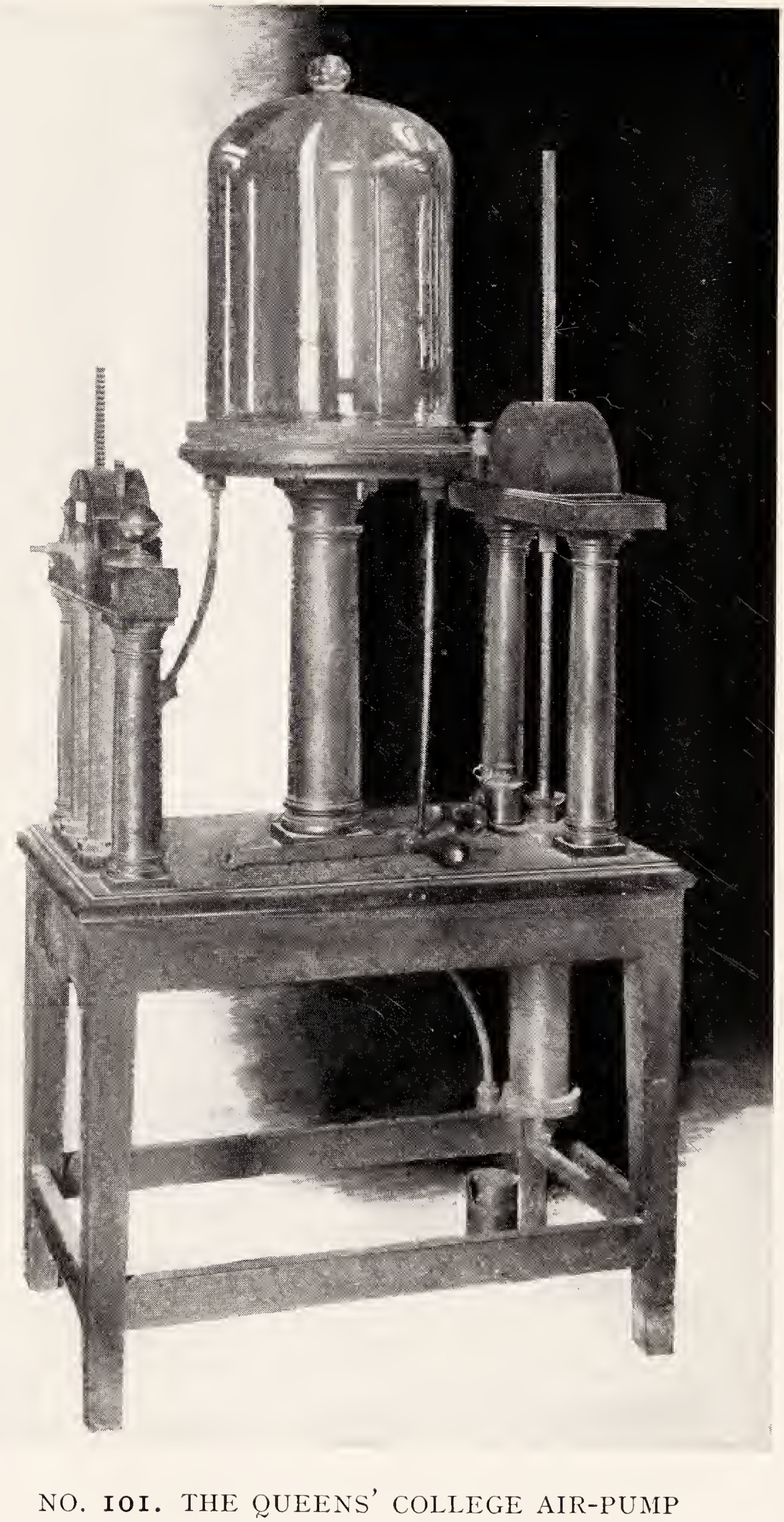
Cavendish Laboratory.



NO. 111. TROUGHTON'S THERMOMETER

NO. 99. BENNETT'S BAROMETER

St. John's College Observatory



NO. 101. THE QUEENS' COLLEGE AIR-PUMP

About 1625 John Harrison (1552–1628) of Eton and King's and high master of St. Paul's 1581–96 retired to a house at Brisingham, Norfolk, in the parlour of which was a picture of a man with a speaking trumpet (put through the wall into the yard) fixed to his mouth, so that upon entering the room one was welcomed by a servant speaking into the trumpet in the yard. (Blomefield, *Norfolk.*)

Propagation of Sound through Air

The Cloister walk of Neville's Court at Trinity is the historic spot where Newton made his rough measurement of the velocity of sound, and where tradition says that he heard a quadruple echo—which the modern undergraduate is more successful in testing than in verifying.

Under date Saturday, June 3, 1665, Alderman Samuel Newton 'the Cambridge antiquary' entered in his Diary the following observation:

All day long was heard ye noyse of gunns in ye ayre, and I myself heard ye noyse of them between 4 & 6 in ye afternoone and again between 9 & 10 the same night.

Sir Isaac Newton came into the Hall of Trinity College and told the other fellows, that there had been an action just then between the Dutch & English, and that the latter had the worst of it. Being asked how he came by this knowledge he said that, being in the observatory, he heard the report of a great firing of cannon, such as could only be between two great fleets, and that as the noise grew louder and louder, he concluded that they drew near to our coasts; and consequently that we had the worst of it, which the event verified.

The guns were heard plainly in London, especially upon the River. (Pepys's *Diary.*)

The gate of Honour of Caius was noted for its resonant quality in the time of Abraham de la Pryme, who has recorded experiments made on 3 Nov. 1693.

Robert Smith (1689–1768), Plumian Professor, 1716–60, see p. 104, published a volume of *Harmonics.*

Sounds inaudible to certain ears were investigated by W. H. Wollaston of Caius, who when visiting friends used sometimes to blow shrill whistles of very high pitch and watch the effect.

107. Pepys's Musarithmica Mirifica. After 1669.

Magdalene College.

A Musical Composing Machine, based on the apparatus described in the *Musurgia Universalis*, Rome, 1650, by Athanasius Kircher.

Like a miniature chest of 119 drawers in 12 tiers. Each drawer being a small board inscribed with bars of music, which may be variously combined to form melodies.

Size 1 foot × 9 in. × 3 in. high.

One 'drawer' is inscribed: *Enneasyllaba et Decasyllaba pen; Long Toni.* I, II, VI, VII, IX, X.

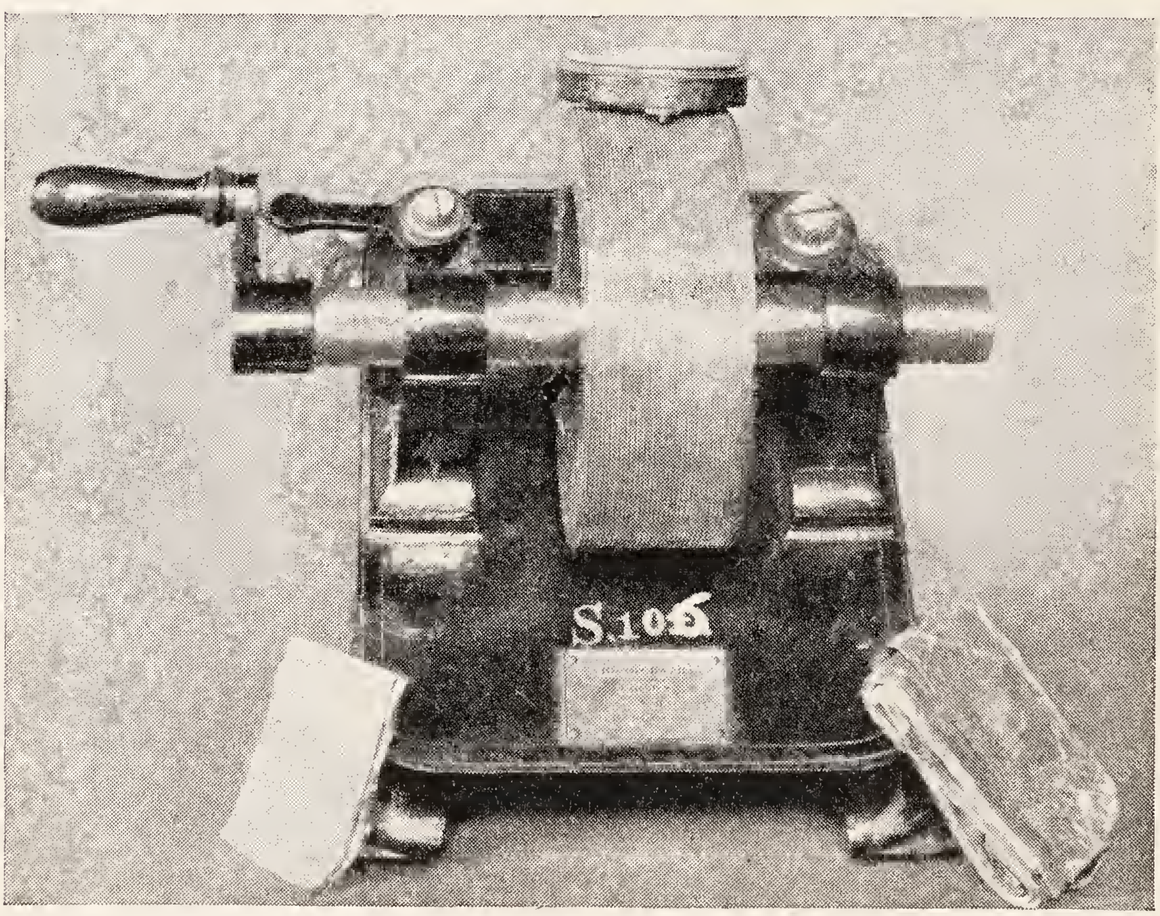
7 7 7 1 2 7 1 7 1
5 5 5 6 6 5 5 5 5
&c.

On back:

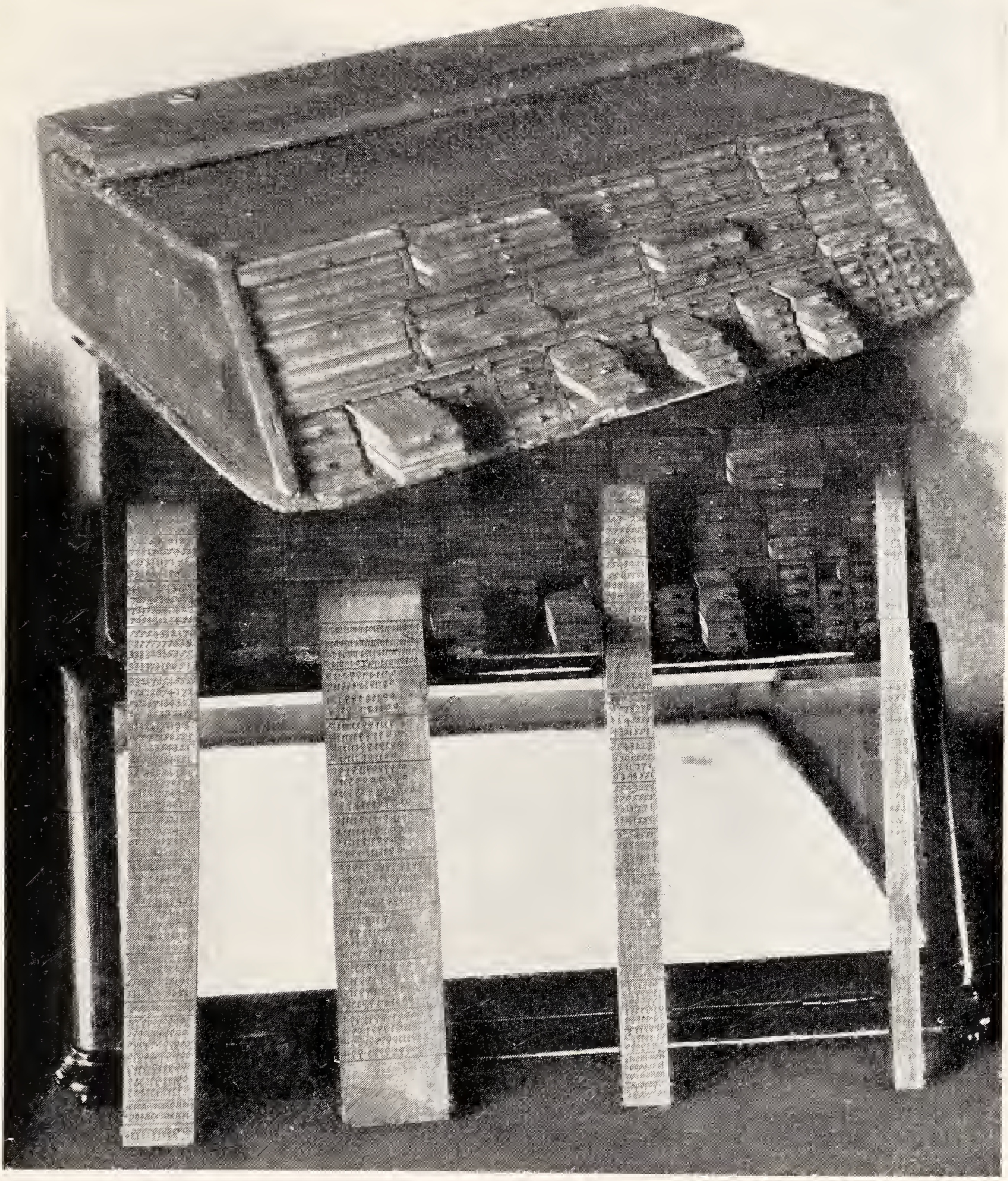
Tempus Metrometrum

108. Edison Phonograph.

Cavendish Laboratory.



Made by 'E. HARDY à Paris'. Marked 'B.S.G.O.G.' With tinfoil for records.



NO. 107. PEPYS'S MUSARITHMICA MIRIFICA

Magdalene College

HEAT

An early determination of the contraction of marble by cold was made in 1752 by Roger Long of Pembroke Hall.

'On this occasion I measured the length of the marble when very much heated by the sun, driving two nails into a long slip of deal so as exactly to clasp it in length, and then throwing cold water thereon, applied the same measure to it, and found it was manifestly shorter when cold. That metals expand by heat and shrink into less dimensions when cold has long been known; I do not find any mention made of the like having been experienced in marble.'

The unpublished papers of Henry Cavendish of Peterhouse show that he determined the specific heats of a number of bodies and also anticipated Black in the discovery of Latent Heat. He has, however, the undisputed credit of having invented a self-registering thermometer in 1757, and of having been the first to construct maximum and minimum thermometers. One of his maximum and minimum instruments is preserved in the Royal Institution. In this instrument a column of mercury in a glass tube with a syphon is acted on by alcohol during its change of volume. The variations in the height of the mercury are repeated by an ivory float, a silken cord, a grooved wheel with a light pointer, moving vertically behind a graduated circle. Cf. *Life and Works of Cavendish*, 9, 477.

The invention of a black-bulb thermometer is due to Professor Watson of Trinity.

Osborne Reynolds (1842–1912) was the son of a 13th wrangler who went into the church. After a brief period in an engineering shop, he went up to Queens' College and graduated 7th wrangler in 1867. In the next year he was appointed to the newly founded chair of Engineering at Owens College, which he held from 1868 to 1905.

His work on turbine pumps is now recognized as having laid the foundation of the great modern development in those appliances, whilst his early investigations on the laws governing the condensation of steam on metal surfaces, and on the communication of heat between a metal surface and a fluid in contact with it, stand in a similar relation to recent improvements in boiler and condenser designs.[1]

[1] Horace Lamb, *Obituary of Osb. Reynolds, Proc. R.S.*, 1913.

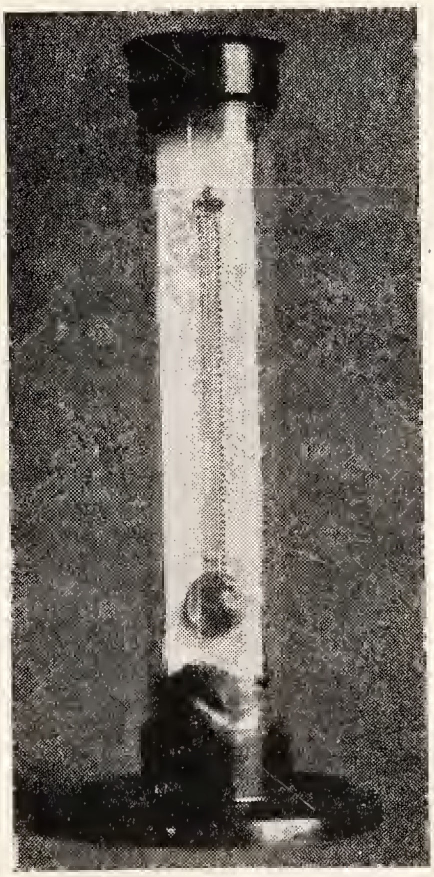
There is an amusing tale about his exposition of the use of a slide-rule. 'Suppose we desire to multiply three by four, we must adjust the slide so that...' and then he described the necessary adjustments. 'Now we arrive at the result; three times four is 11·8' he declared to the amusement of the class.

He was the first to give the correct explanation of Crookes's Radiometer.

Crookes arrived at the invention of the Radiometer after noticing certain unexpected variations in weighing in tubes exhausted of air. He stated in his Royal Society paper of 1873 that he hoped to discover the cause of gravitation 'in the radiant molecular energy of cosmical masses'.

The Cryophorus was the invention of Wollaston of Caius College.

Thermometers



109. **Thermometer** of the Accademia del Cimento. **1660.**

Cavendish Laboratory.

Length of tube $4\frac{3}{8}$ inches; height of containing vessel $7\frac{7}{8}$ inches.

Given to C. Babbage by the Grand Duke of Tuscany. Pres. by Lt.-Col. Babbage 1877.

110. **Thermometer** by 'Nairne'. **c. 1767.**

St. John's College.

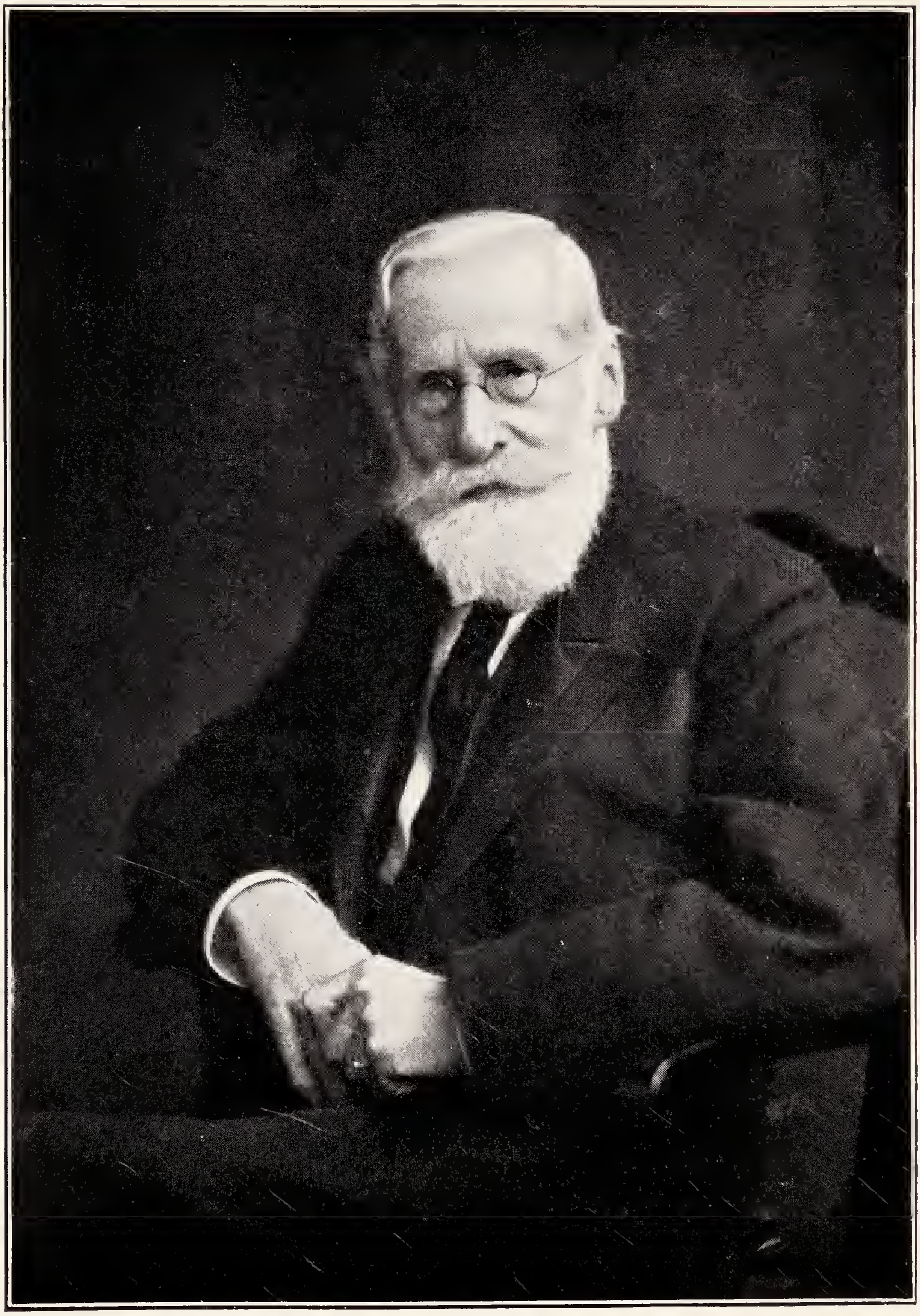
2-foot tube.

111. **Thermometer** by 'Troughton, London'. **c. 1780.**

St. John's College.

112. **Thermometer** by Bréguet. **c. 1820.**

Cavendish Laboratory.



SIR WILLIAM CROOKES

By courtesy of the British Association

113. Standardized Thermometers used by Prof. Miller when making the Standard Pound in the basement of Cockerell's Building.

Dept. of Mineralogy.

B.	By *Bunten* of Paris	1843	—23° to 107° C.
C.	,, ,,	1841	—24° to 41° C.
D.	,, ,,	1841	—25° to 53° C.
K.	No. 43 *Kew Observatory* July 1853.		

114. Maxwell's Apparatus for Experiments on the Viscosity of Gases. **1865–6.**

Cavendish Laboratory.

In the vessel to be filled with the gases were a number of superposed circular discs, half of which are fixed, while the others which are attached to a steel torsion wire are free to turn.

Constructed at King's College, London. The experiments led Maxwell to the conclusion that 'the coefficient of internal friction is independent of the density of any particular kind of gas' and 'that the viscosity is directly proportional to the temperature measured from the absolute zero of the air thermometer'.

J. Clerk Maxwell, Bakerian Lecture, *Phil. Trans.* 1866.

115. Maxwell's Models of Thermodynamic Surfaces.

Cavendish Laboratory.

116. Crookes's Radiometer. 1896.

Cavendish Laboratory.

LIGHT AND COLOUR

A desire to increase the power of the Eye, whether in health or disease, by artificial means has always been a strong incentive among inventors of the highest class. Yet it was not until well on in the seventeenth century that really serviceable optical instruments of power were evolved. As every one knows, the ground had been prepared by the writings of Roger Bacon and the telescopes of Leonard Digges, Hariot and Galileo, but at Cambridge we have found no mention of the actual performance of an early optical instrument of power beyond one visualized by a theologian of Emmanuel College, N. Culverwell, in his *Spiritual Optics: or, a Glasse discovering the weaknesse and imperfection of a Christian's knowledge in this Life.* 1651.

It is believed that while Newton was at home in 1665–6 he devised instruments for grinding lenses to particular forms other than spherical. But already in 1660 at the age of twenty-three years he had begun his historic preliminary experiments on the incidence of a beam of white light upon a prism, and on its emergence as a band of colour. 'I procured me a triangular glass prism [at Sturbridge Fair] to try therewith the celebrated' experiments. From these experiments he deduced the proposition that a lens, and, *a fortiori*, a refracting telescope made of lenses, cannot bring different colours to the same focus, and must therefore produce blurred and coloured images. But as it also occurred to him that the images formed by mirrors are free from this defect of 'chromatic aberration' he adopted the reflector as the ideal for a perfect telescope.

Full of enthusiasm to work out his idea, he completed the first reflecting telescope known to history in 1668, the year of his election to a Major Fellowship at Trinity. Its aperture was only 1 inch and its length 6 inches, yet it bore a magnification of 40 times and Newton saw with it the disc and 4 satellites of Jupiter, and the phases of Venus with difficulty. Later he made a slightly better telescope which he sent for exhibition at the Royal Society. The King saw and admired it, and Newton was elected a Fellow on January 11, 1672.

Less than a month later he sent in a paper on the

Spectrum and the nature of colour in which he explained the elongation of the band, viz. that the divergent coloured beam really consisted of a number of beams of different colours, each of which had been bent to a different degree when passing through the prism. He showed that by passing such a bundle of coloured beams through a second prism, they could be reunited so as to form a white beam again.

The coloured light that suffered least bending was red, and the light that was most bent was violet, from which it follows that a convex lens cannot produce a single white image at one focus, but must originate a number of coloured images each at a different distance from the lens.

Thus his little reflecting telescope was justified. It brought all its rays to a single focus. And, if the proof of the pudding be the eating, we have this proof in the successful performance of the great 100-inch reflector at Mount Wilson in California.

It must not be supposed that Newton's ideas on Colour came to him all at once, like Minerva from the brain of Zeus. It has been pointed out that when he helped his friend Isaac Barrow in the publication of Lectures on Optics, he left Barrow's erroneous notion about Colour uncorrected. So he was probably still in the uncertain stage himself as late as 1669 or later. When the nature of light itself came under discussion, Newton abstained from committing himself. It was 'something or other propagated every way in straight lines from luminous bodies'.

Here we may interpolate the effect of Newton's teaching upon the intelligent 'man in the street', as exemplified by the Hon. Roger North about 1680. His reactions are always of interest:

'I have had much pleasure in the theory of light, which leads to optics and the other mathematical sciences derived from it, all which have their foundation from the general laws of nature, which regulate the effect of impulses of one body upon another, and consequently on the true government of reflection and refraction. It is by them we demonstrate that the angle of incidence shall be always equal to the angle of reflection, and that refractions shall wend one way or other according as the light passeth into or from a more dense medium, which are

rules so steady and also important in all the doctrine of light that they seem laws depending on the immediate will of the great Author of nature, and not derivative as they plainly appear from the system of nature, as I have elsewhere proposed it, which still magnifies the artifice and Artificer of nature. For that a single principle or two should produce such infinitely various effects, and those be made sensible at such distances, and so plain as we find by vision, as also by hearing, is a much greater perfection than if consisting of mere contrivances, or (as the heathen fancied) if a God presided in the government of every branch of nature.

. . . .

'As to the reason of Light, I have ever admired Mr. Newton's hypothesis as new and most exquisitely thought, which is, in short, that light, generally speaking, is a blended mixture of all colours, and that these colours are the different effects of certain rays, as blue is of rays which are of that sort, and diversified from others as producing that effect; so red, green, yellow, &c.; and these coloured rays are not refrangible to the same angle, but some to a greater and some less, which makes the distinction of colours in all refractions. And they are not accidentally created by that action, but only separated, existing all. But still there wants a physical solution of this hypothesis, without which, however plausible, it will not be admitted. I have endeavoured at this work, and conceive I know the reason of light, but whether it will square with this hypothesis or not, does not positively determine. My solution is this, that when a force falls upon a fluid there are two sorts of action communicated, one progressive, as waves on the surface of water, which produces sound, the other in an instant, by reason of the perpetual contiguity of water, this is light; and our corresponding organs are fitted to receive, augment, and expose proper nerves to convey the sense of it to the seat of perception. As the ear has a broad verge to take in a large compass of air, which must go contracting, and consequently accelerating, to the tympanum or drum within; so also the eye, by refraction, drives the whole capacity into a less compass, not unlike a burning glass, which gives a greater force upon the retina or optic nerve. Now as to light, what we observe comes, for the most part, from fire. The true understanding of that is necessary to the knowledge of light. Fire, I take it, is not

found, but either in the centre of a vortex or where some atmosphere presseth; the former is the sun and fixed stars, the other our culinary fire. And it is no other but a fierce agitation of the minute part of bodies of which combustible solids are composed. If this happen in ether, so as there is no room for the grosser matter to give way and inclose this combustion, it immediately blends in the ether, and, dispersing every way, is lost. But in our atmosphere the air presses in all bodies, and if one is disposed to ascend until the action is arrived to such a pitch as to have force to throw off the pressing atmosphere, and have free scope for the action to work, it does not take the shape of fire, that is light; for until it takes a light we call the action heat or fermentation, and not fire. Then to bring this to the purpose of seeing, an action which has force to beat off the atmosphere, is of force to make an impression on our optic nerves, but this is not done *in toto* but *particulatim*. For the stroke of each part of that fire, or burning body, upon the contiguous part of the atmosphere, is by the rule of impulses carried *in fluids* every way in right lines, so that light is composed of infinite (if I may so speak) pulses of minute parts upon the air, which perhaps, considering the variety of form and force concerned in these impulses, and that everyone has its distinct effect, this solution may quadrate with Mr. Newton's hypothesis. But I cease to prosecute these matters further, leaving them to their places in the notes I have made of my thoughts upon most physical heads; but this being a most admirable theory, I could not avoid touching upon it *en passant*.

Newton's explanation did not satisfy Hooke or Huygens, both of whom ardently supported a wave-theory, on the basis of which they raised objections to Newton's presentation of his case. Newton had not got it in his nature to face adverse criticism—he merely became angry and withdrew into his shell. And in this case he withdrew his treatise on Optics too, for 30 years, until after all the Fellows of the Royal Society in London had attended Hooke's funeral.

Newton's Rings

When the Colours of thin transparent films were a subject of interest to the Royal Society in 1675, Boyle and Hooke described the phenomenon in thin plates of mica,

but they were unable to measure the thickness of the film producing the colour. Newton produced the same effect by placing the surface of a spherical lens of large radius in contact with a flat plate, thus enclosing a film of air of measurable thicknesses at various radial distances from the centre of contact. By measuring the radii of the rings of colour he was able to calculate the thicknesses of the air film that produced them.

It is, of course, now known to be capable of easy explanation on the principle of interference, and Hooke's and Huygens's wave-theory, but Newton either could not or would not accept this, and preferred to regard them as the effects of a ray of light not being homogeneous throughout its length but varying longitudinally, or having what Newton called 'fits'.

Further work done by him dealt with the bending of light-rays when passing close to the edge of a body. The effect is that which we now name Diffraction, and which was correctly explained by Hooke. Owing to Newton's overwhelming prestige, the wave-theory of light remained in abeyance for more than a century, when once again a Cambridge physicist, Young, and a continental worker, Fresnel, proved its great serviceability.

Robert Smith (1689–1768), master of Trinity, second Plumian Professor 1742, and founder of Smith's prizes, wrote a more comprehensive treatise on *Optics* 1738, which had a wide circulation and greatly stimulated the construction of optical apparatus. It is now the most helpful historical treatise on Light of its time.

The phenomenon of Haloes which had been discussed by Newton in 1664 (cf. *Optics*) was again taken up by James Wood, Master of St. John's, who contributed a small paper thereon to the Memoirs of the Manchester Literary and Philosophical Society in 1790. He, too, published a textbook on the *Elements of Optics* in 1798.

A small treatise on *Optics* of no great worth was published by Dr. Kipling of St. John's, who had been senior wrangler and became deputy to the Professor of Divinity in 1787.

W. Hyde Wollaston excelled in the devising of optical apparatus. He was the first to use the total-reflexion method for the determination of refractive indices, and

also the dark lines of the solar spectrum. In 1802 he had seen the bright bands that appear when the blue light at the base of a candle flame is passed through a prism, but he regarded the black bands in the solar spectrum as lines of separation between the different colours.

His inventions included the following:

1803 Periscopic Spectacles for oblique vision.

1807 Camera Lucida. In attempting to fix the image of the beautiful scenery of Lake Como seen with the aid of Wollaston's Camera Lucida, W. H. Fox Talbot was led to photography.

1809 Reflecting Goniometer.

1812 Periscopic Camera Obscura and Microscope.

1820 Double-image Prism described in a paper 'On the Method of cutting Rock Crystals for Micrometers'.

1829 Microscopic Doublet, still used as an objective for compound microscopes.

His contributions to Theoretical Optics included a demonstration that measurement of the refractive index of Iceland Spar in different directions agreed with Christian Huygens's construction for the wave surface (1690).

The 'Chemical effects of Light' were discussed by him in 1804.

Thomas Young, 1773–1829, had studied medicine at Edinburgh and Göttingen before he came up to Emmanuel College whence he took his degree in 1799. But he had a mathematical bent which did not contribute to his success with patients, who desired to be told that they would certainly recover, instead of hearing the mathematical chances of their doing so. After the age of 25 he found his true *métier*, and began to publish those researches on the interference of waves and light which by removing the difficulties to the adoption of the undulatory theory of Light have immortalized his name.

Incidentally he established the fact that all colours may be matched by the mixture of three properly selected primary colours.

His *Lectures of Natural Philosophy and the Mechanical Arts*, published in 1807 in two quarto volumes, give a wonderful display of his extraordinary power.

It is interesting to note that the study of the undulatory theory of light did not reach Scotland before the end of 1834, when J. D. Forbes acknowledged the assistance he had received from Airy's 'valuable practical lessons'.

The higher mathematical analysis of the Laws of Light became possible after the work of Fresnel and Thomas Young, and after Arago and Brewster had discovered the beautiful colour effects of polarized light transmitted through plates cut out of crystals.

In Arago's experiments a parallel beam of light was used, and the effects were satisfactorily explained by Fresnel. But when several such beams were sent through the plate in various directions, the effects became more complicated and beautiful, coloured bands becoming crossed by light or dark brushes of various shapes, of which the mathematical analysis is more difficult.

Among those who treated these problems mathematically, George Biddell Airy (1801–1881), Plumian Professor of Trinity College, was one of the most successful. Signally so is his paper on the coloured curves observed in crystalline plates, and especially on the spiral curves produced by quartz under certain conditions.

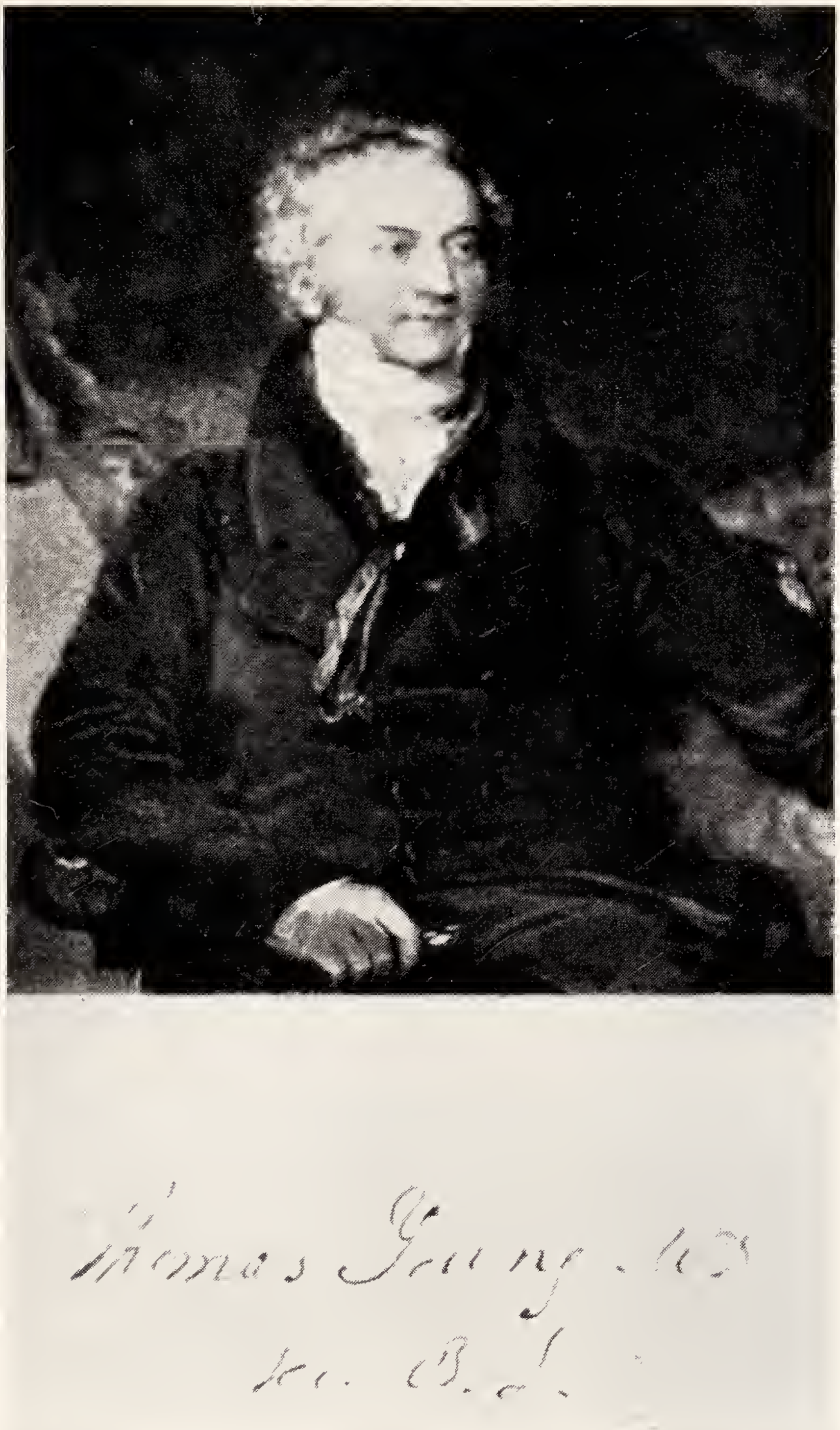
The violet of the Rainbow is frequently followed by a dark red and a succession of colours sometimes twice repeated. Young by 1807 had already explained these supernumerary rainbows as due to an interference of light, which manifests itself when the sizes of the raindrops are nearly equal, but Airy has the credit of the first mathematical analysis.

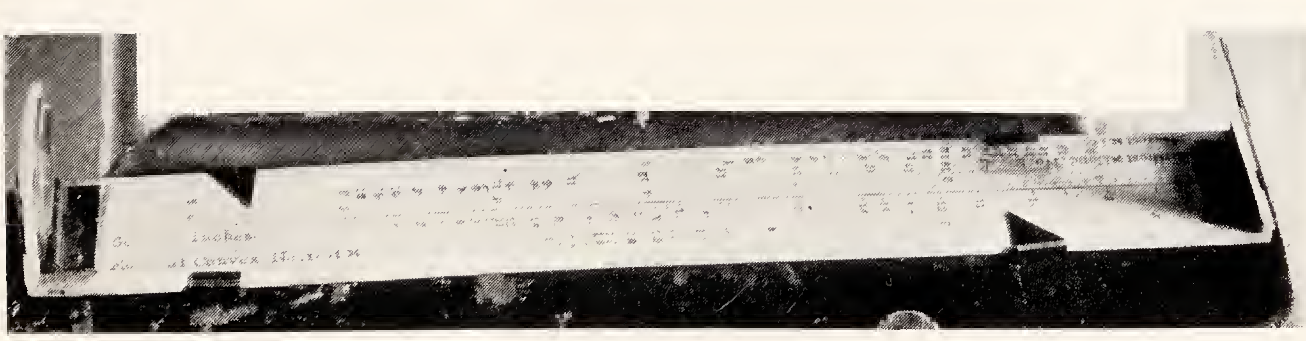
George Green (1793–1841) of Caius College turned his powerful mind to Optics during the last few years of his life and published the result in two papers.

Reflection and Refraction of Light at the common Surface of two non-crystallised Media.

Light was treated for the first time as a special case of waves passing through a perfectly elastic body. So great an advance was this that many regard George Green as the founder (after Newton) of the Cambridge School of Mathematical Physics.

He did not complicate his problem by considering the





THOMAS YOUNG AND HIS OPTOMETER
Royal Institution

ultimate constitution of the ether, or the arrangement of molecules in a medium. He merely assumed that the properties of the luminiferous media were in agreement with the principle of the conservation of energy. His treatment dealt with the problems of the transmission, reflection and refraction of waves passing through homogeneous elastic bodies. From this he obtained mathematical formulae which fitted some cases, but not all.

Philip Kelland (1808–79), senior wrangler, Queens' College, wrote on the undulatory theory of Light.

The article *Light* in the *Encyclopaedia Metropolitana* was contributed by Sir John Herschel.

The matter was taken further by George Gabriel Stokes (1819–1903), Pembroke College, c. 1840–50, who made a special study of the aberration of light and of the phenomena of double refraction. He wrote from the point of view of the elastic solid theory of Light, now abandoned, but his writings on the Dynamical Theory of Diffraction (1849) are of lasting value.

It was to Stokes that we owe the first satisfactory account of Fluorescence (1852), and of the ultra-violet spectrum.

Athanasius Kirchmajer in 1680 and Robert Boyle had already observed that infusions made from certain woods showed different colours when examined by transmitted or by reflected light, and their knowledge was extended by John Herschel and Brewster, but no wider investigation of the remarkable phenomenon was made before 1852 when Stokes took up the matter. He caused a beam of sunlight from a slit in a shutter to pass through three prisms, and form a spectrum on a screen in a dark room. Solutions of the substances to be examined, e.g. sulphate of quinine or esculine, were placed in the course of the coloured rays of the spectrum without revealing anything remarkable, but when they were moved into the region beyond the violet they began to shine with a strong blue light. That such ultra-violet rays, having a strong chemical action, actually existed was already known, but Stokes found that by using prisms made of quartz, he could obtain their effect more strongly and along a wider range, for glass absorbed them. The practical and theoretical importance

of this discovery is that certain substances have the power of making ultra-violet rays visible, or in other words of changing the wave-length of light rays from the very short waves of the ultra-violet into the longer waves of blue. Further he proved that the refrangibility of light can also be altered by substances, of which fluor spar is a type, which absorb incident light and emit it again with a changed period of oscillation. To such phenomena he gave the name of 'fluorescence'.

The *Analysis of Spectra* from the point of view of the numerical relations between the frequencies of spectral lines was one of the last investigations (1912–22) of Dr. William Mitchinson Hicks (1850–1934) of St. John's, first Vice-Chancellor of Sheffield University.

Telescope

The 25-inch achromatic refractor now being used in the Astrophysical Observatory at Cambridge was constructed by Messrs. Cooke of York in 1871. The lenses were ground by this firm out of a pair of large discs of crown and flint glass of 26 inches in diameter, which Messrs. Chance of Birmingham had shown in the exhibition of 1862. No telescope with a larger aperture than 16 inches had been made before. It was presented by Robert Stirling Newall (1812–89) in 1889.

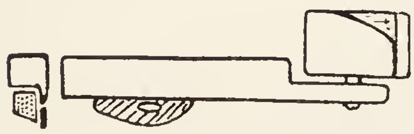
John Hopkinson (1849–98) of Trinity, senior wrangler in 1871, was engaged by Messrs. Chance Bros. at Birmingham as engineering manager. For six years he devoted himself to the improvement of lighthouse illumination and introduced the system of group flashing lights which is now extensively used.

Much important optical work on a commercial scale was done by Sir Charles Parsons (of St. John's College). At Heaton after 1890 he made parabolic reflectors for searchlights. Later he acquired a controlling interest in Ross Limited, of which he became chairman. He then purchased the Derby Crown Glass Works and developed the Parsons Optical Glass Company for making large discs of optical glass, then went into partnership with Sir Howard Grubb & Co., and began making large telescopes, e.g. the 74-inch Reflecting Equatorial for Toronto.

117. **Thomas Young's Optometer.** **1801.**
Royal Institution.

118. **Wollaston's Spectacles for Stereoscopic vision.**
Cavendish Laboratory. c. 1803.

119. **Camera Lucida.** **? 1786, 1807.**
Cavendish Laboratory.



Wollaston's original Model in wooden frame. A label '1786' may indicate the date of the invention though it was not put on the market until 1812.

120. **Optical Lanterns.** **After 1808.**

a. By Watkins & Hill, Charing Cross. St. John's College.
b. By Newton & Co., made for Sir David Salomons.

121. **Stokes's Discs for the Phenakistoscope.**
Cavendish Laboratory.

122. **Maxwell's Zoetrope.** **c. 1850.**

The parent invention or Daedaleum was made by Dr. Horner of Bristol in 1838, which was patented by Devignes

in 1860. Maxwell fitted his with concave lenses, so as to produce images at the centre of rotation, and used the apparatus to show vortex rings passing through one another, as well as 'movies' of more popular human interest.

123. Maxwell's Stereoscope.

Cavendish Laboratory.

By Elliot Bros., 449 Strand, London.

124. Maxwell's Colour Top. 1855.

Cavendish Laboratory.

Three sectors coloured vermilion, emerald green, and ultramarine can be exposed in varying proportions so as to imitate any desired colour. Within them are similarly variable black and white sectors. With this instrument Maxwell obtained his Colour equations. Cf. paper read to Royal Scottish Society of Arts, 1855.

125. Maxwell's Colour Box. 1856–60.

Cavendish Laboratory.

Phil. Trans., March 1860.

126. Slides used in experiments on Colour. c. 1864.

Used by Maxwell at his Royal Institution Lecture.

127. Heliostat. c. 1880.

Sir G. Stokes collection, Dept. of Mineralogy.

'J. T. Silbermann Invent Duboscq Soleil. No. 56.'

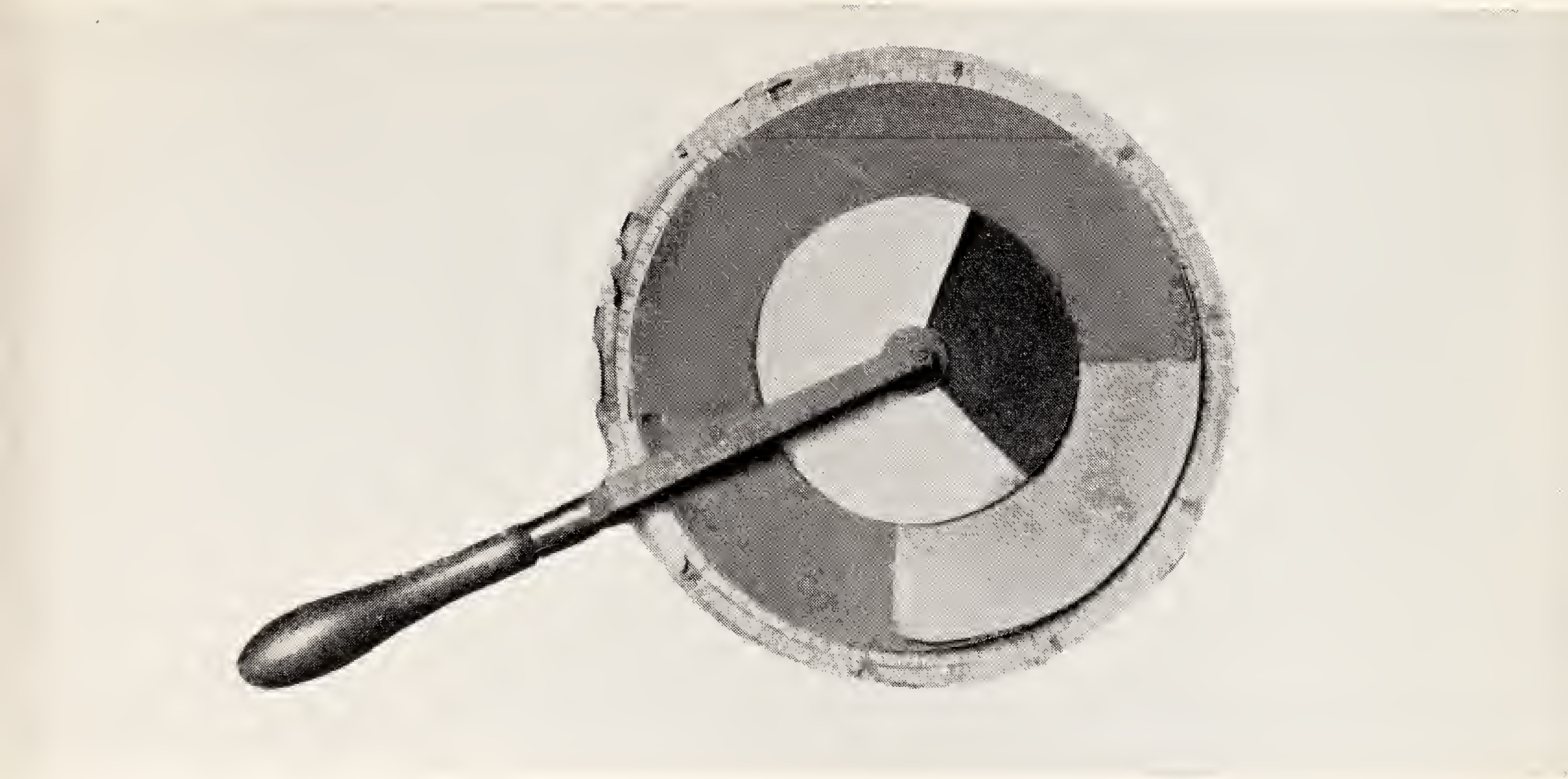
16 inches high × 6 inches on 3 levelling screws. The orientation circle is inscribed 'Midi, Minuit, Est, Ouest.'

128. Heliostat by Spencer & Son, Dublin. c. 1830.

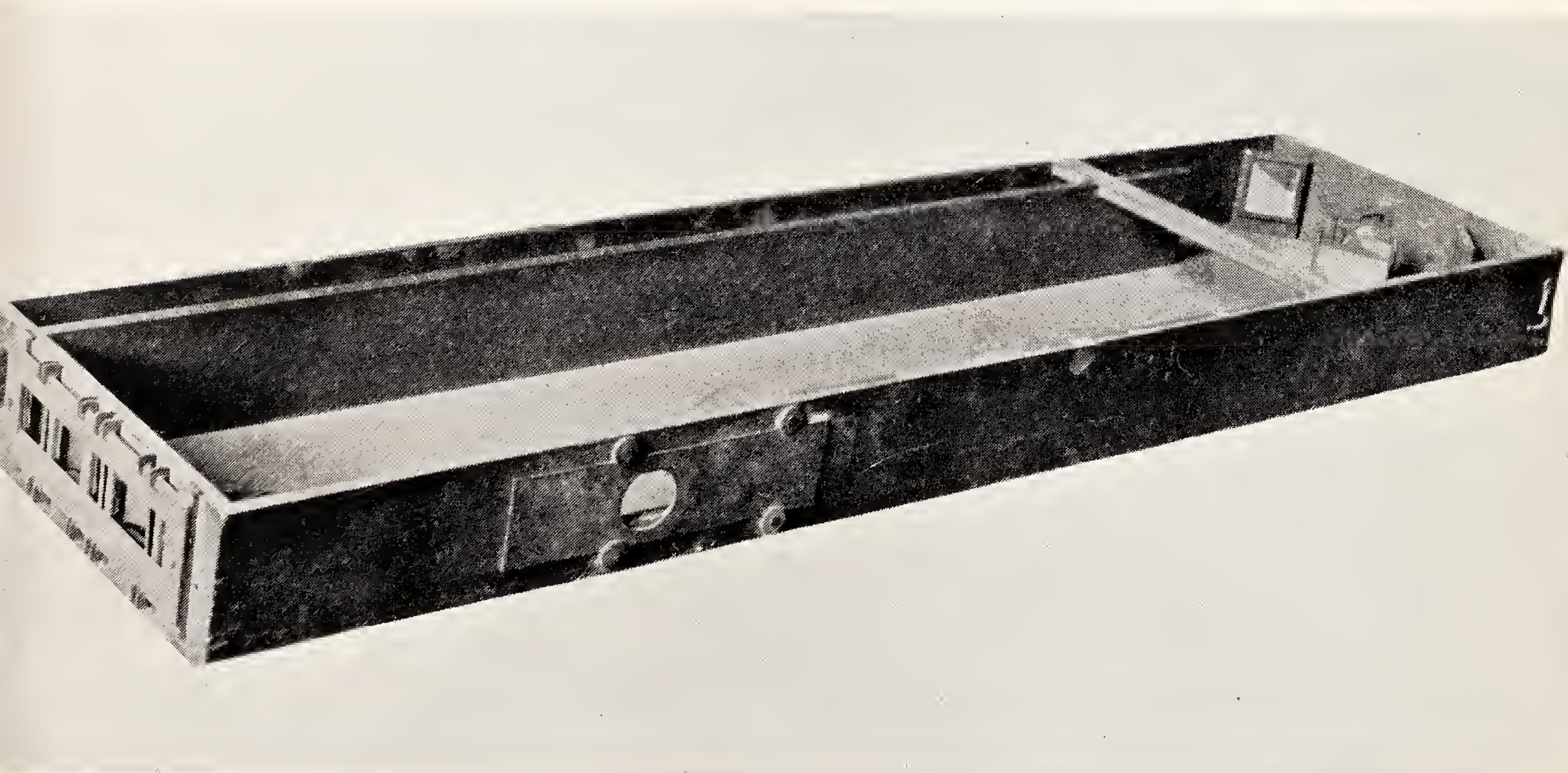
Mineralogical Museum.

129. Uranium Glass (Stokes Collection).

Cavendish Laboratory.



NO. 124. MAXWELL'S COLOUR TOP



NO. 125. MAXWELL'S COLOUR BOX

MAGNETISM

The *De Magnete* published in 1600 by William Gilbert (1540–1603) of St. John's, is one of the chief landmarks in the history of science. It was a systematic résumé of all that was then known of the mysterious forces inherent in magnets. The phenomena of the Variation of the Compass needle and of its dip are fully discussed, and after a comparison with a spherical loadstone or terella, Gilbert advanced the then novel theory that the Earth itself is a great Magnet. Moreover, through his acquaintance with the demagnetization of iron that occurs when it is strongly heated, he paved the way for the conception of magnetization as a molecular phenomenon.

The epoch-making experiments on Electricity in the second book of the *De Magnete* will receive special mention presently.

In 1634–5 John Pell of Trinity published his *Remarks on Gellihand's Discourse mathematical on the Variation of the Magnetic Needle,* but that was three years after his incorporation at Oxford.

Samuel Ward, Master of Sidney College, published a theological work, entitled *Magnetis Reductorium Theologicum Tropologicum, in quo ejus novVs verVs et sVpreMVs VsVs InDICatVr. Londini* 1637, that was undoubtedly produced as the result of reading the *De Magnete.* The polarity of a magnet served the author with an attractive analogy with Christianity.

Terrestrial Magnetism was the subject of practical investigation by G. B. Airy (1801–81) when he was living at Greenwich as Astronomer Royal. The building of ships of iron was found to lead to deflexion of their compasses by the magnetism of the ship, with the result that navigation was seriously menaced. Airy, having secured an iron ship for the experiment, found that the amount of the deviation of the compass due to the iron of the ship could be neutralized by placing small permanent magnets in suitable positions near the compass.

Although he was not a member of the University at the time of his magnetic investigations, we must here mention

the name of J. A. Ewing (see p. 90) of Edinburgh. As a pupil of Lord Kelvin he had noted the tendency of magnetization to linger after the application of the magnetizing force, a delay to which he gave the name of *hysteresis* in 1881.

ELECTRICITY

In his second book of the *De Magnete* Gilbert in 1600 was the first man to throw light on the behaviour of electrified bodies, which he tested with a *versorium*, or electroscope of his own devising. He distinguished between 'magneticks' and 'electricks', because while all things move towards the latter, only 'a lodestone appeals to the former'.

As early as 1708 Electrical experiments were made in Corpus Christi College by Stephen Gray, 'the first eminent propagator of electricity', when he came to visit his nephew John Gray, who was then a medical student in that house. The experiments were done with a 'cylindric glass tube' in the presence of Stukeley. John Gray took his M.B. in 1711, and went into medical practice at Canterbury. Stephen Gray was honoured by being the first recipient of the Copley Medal of the Royal Society in 1731. But subsequent advance was slow.

About 1747 Dr. Richard Watson, afterwards Prof. of Chemistry, observed, almost simultaneously with Franklin, 'positive and negative' (or as he called them, 'more rare' and 'more dense') electricity, and that when an electric body is excited, the electricity is not created, but collected. Later his electric experiments were on so large a scale as to excite the admiration of Professor van Musschenbroek of Leyden, whose friend Cunaeus, it will be remembered, was the first to experience a shock from a potential 'Leyden Jar'. (*Anecdotes of Ri. Watson*, Wordsworth.)

The interesting experiments that were being made everywhere with Frictional Electricity about the middle of the 18th century were certainly repeated in private by Cavendish, who went on to further discoveries but never published them. His interest in the science of electricity is

proved by the publication of a paper on *An Attempt to Explain some of the Principal Phenomena of Electricity by Means of an Elastic Fluid* (*Phil. Trans.* 1771).

The Hon. Henry Cavendish (1731–1810) of Peterhouse was the son of Lord Charles Cavendish who published an account of the capillary depression of mercury in glass tubes, and received the Copley medal of the Royal Society for having been the first to construct maximum and minimum thermometers. From 1749 to 1753 he was in residence in Cambridge.

It is difficult or impossible to evaluate what the world might have owed to Henry Cavendish if he had only condescended to publish his results for the benefit of others. He cared more for investigation than for publication, and it was not before 1879, when his manuscripts were examined by Clerk Maxwell and later by Larmor, that it was possible to realize the extent to which Cavendish had anticipated the results of subsequent researches of the first importance. But, as in the case of Dollond v. Chester More Hall, 'it was not the person who locked his invention in his scrutoire that ought to profit from such invention, but he who brought it forth for the benefit of mankind'.

It is therefore necessary to discriminate between what Cavendish did publish and what he might have, but did not publish.

Among the might-have-beens was his measurement of the electrostatic capacity of bodies, anticipating Faraday in the discovery that different substances have different inductive capacities. Working with a roughly made electroscope, he showed that the electric current is proportional to the electromotive force, thus anticipating Ohm. He compared the electric resistance of iron with that of rainwater and of different salt solutions. Relative resistance was also measured by discharging Leyden jars through conductors made of different materials, and by adjusting their length until he estimated the shocks as equal, when also passed through his own body, and his results were surprisingly accurate. We must be grateful to him for not having deprived Faraday of the pleasure of a rediscovery.

Some of his apparatus may still be seen at Chatsworth. It consists of Leyden jars without covers, a cylinder

Electrical Machine, a few glass tubes, probably the remains of eudiometers, and a very large insulating stand made of a piece of thick glass rod covered with shellac varnish.

Cavendish on the Torpedo or Electric fish

The shocks which Mediterranean fishermen had long learnt to associate with the Torpedo were described by John Walsh, F.R.S., who in 1773 suggested that they were electrical; but his view was not generally accepted, because it seemed impossible in a medium which is so good a conductor of electricity as sea-water is known to be. This argument was finally met by Cavendish, who constructed a model torpedo which he could immerse in salt water yet nevertheless cause to deliver shocks to a manipulator.

Clerk Maxwell notes that Cavendish is not known to have admitted any visitors to his laboratory except on this occasion when the imitation electric fish was demonstrated.

The study of current electricity following upon the first discovery in the laboratory of Luigi Galvani in 1789 made more rapid progress, for by 1820 Oersted was able to demonstrate the magnetic field produced by a current.

W. Hyde Wollaston, of Trinity College, established the principle that electricity produced by galvanic action and by friction are of the same nature, but that that of the voltaic cell was due to the oxidation of zinc. He succeeded in decomposing water by the sparks of a frictional electric machine in the same manner as had been done by voltaic cells.

In 1821 he noticed that there is 'a power . . . acting circumferentially round the axis of a wire carrying a current', and that therefore a conductor along which a current is flowing should revolve on its axis in a suitable magnetic field. The demonstration was subsequently achieved by Faraday.

Wollaston took delight in producing great results with small and simple means. When on a particular occasion Children had shown him the brilliant results obtainable by the use of a huge galvanic battery, Wollaston took from his waistcoat-pocket a small thimble, which he had fitted as a battery, and pouring into it the contents of a

small vial, he heated a platinum wire, drawn as fine as gossamer, to incandescence.

This cell, long in the possession of the Royal Society, has been deposited in the Museum for the History of Science in the Old Ashmolean at Oxford.

James Cumming (1777–1861), fellow of Trinity and professor of Chemistry in 1823, determined the thermo-electric order of most of the commoner metals within a few months of the discovery of Thermo-electricity by Seebeck of Berlin (Dyer, *Privil. Camb.* iii. 90). He also showed Oersted's experiments on the deflexion of a magnetic needle by an electric current, and observed 'Here we have the principle of the Electric Telegraph'. His papers in Thomson's *Annals of Philosophy*, 1823–4, have been described as 'landmarks in electro-magnetism and thermo-electricity', which last was stated by Tait in his Rede Lecture to have been independently discovered by him (*Nature*, May 1873, p. 86).

He was the first to show that when the temperature of one junction of certain thermo-electric circuits was gradually raised, the current gradually rose to a maximum, then fell off, and finally was reversed at a red heat.

The delicacy of Electroscopes was very greatly improved by him. His principal contributions were:

On the Development of Electro-Magnetism by Heat. Cambridge Philos. Trans. ii. 1823, pp. 47–76.

A Manual of Electro-Dynamics.

Report on Thermo-Electricity, B.A. Reports 1831–2.

A paper on Electricity and Magnetism by George Green (1793–1841) is recognized as a most important contribution to science. In this the name 'potential', which had been suggested by Euler in 1744, is employed and defined. It is a term which has proved of such universal utility in all branches of physics owing to its nominal as well as real connexion with the conception of 'potential energy'.

In his great work on *Electricity and Magnetism* 1873 Maxwell summed up the results of his previous papers, and showed that a physical basis for a theory of electric and magnetic phenomena was not only possible but an assured fact. For this purpose he adopted Huygens's luminiferous ether, but whereas Huygens had in 1690 hypothecated

electric waves as the method of propagation of light, Maxwell brought forward the idea of electro-magnetic waves (in 1864), after ascertaining that the theoretical speed of such waves worked out at 186,000 miles per second, or at identically the measured speed of light. As is well known, the speeds of light-waves and electric waves were only proved experimentally to be equal twenty-three years later, when Hertz in 1887, by devising a means of detecting electro-magnetic waves, not only measured their speed, but made wireless telegraphy a possibility.

The Dynamo

Between 1850 and 1860 many attempts were made to increase the intensity of electric currents obtained by electro-dynamic induction. In 1867 Henry Wilde (1833–1919) made a composite machine in which an electric current, produced by an armature, rotated in the magnetic field of a permanent magnet, fed a second machine in which the permanent magnets were replaced by electro-magnets, which produced a still more powerful current, and this was led into a third machine. His paper, *Experimental Researches on Magnetism and Electricity*, *P.R.S.* xv, p. 107, read to the Royal Society in 1866, was the first step in the production of powerful electric currents suitable for the needs of industry.

In 1878 John Hopkinson (1849–98) of Trinity came to London and conducted classic researches on the efficiency of dynamo-electric machines. He was the first to establish the relation between the magnetic flux and the line-integral of the magnetic force round the circuit as a whole, whereby a methodical treatment of dynamo design was possible for the first time.

Here the broad principle he established was of fundamental importance to the practice of electrical engineering. A knowledge of physics determines the creative work of the engineer. Thus Hopkinson invented his three-wire system of distribution, so widely used for electric lighting, and his series-parallel control for electric locomotives.

George Chrystal (1851–1911) was the first to carry out original research in the Cavendish Laboratory, where

he tested the truth of Ohm's Law[1] to a degree of accuracy far surpassing all previous work. In 1879 he was elected to the Edinburgh chair of mathematics, and, unlike many of his colleagues, devoted his vacations to practical work in Tait's laboratory. By his Differential Telephone he measured induction coefficients in coils whose resistances were balanced in a Wheatstone's Bridge.

The late 'seventies and early 'eighties gave us the telephone, the phonograph, incandescent lamp, dynamo in practical form, electric motor, storage battery, transformer, internal combustion engine using liquid fuel, cold storage, idea of public electric supply, use of alternating currents, potentiality of electricity as an agent for lighting, for traction and for the conveyance and distribution of power.

The researches of CROOKES on high vacua had led to great improvements in the technique of the construction and evacuation of glass vessels, fitted with electrodes. When electric currents of high potential are passed through such vessels a vivid glow appears near the negative electrode. Physicists came to the conclusion that gases which are normally non-conductors could be made to conduct electricity by providing them with carriers analogous to the ions that exist in liquids. Moreover, it was suggested that gases could be ionized, and that electricity, like matter, has an atomic constitution. To prove this it was necessary to show that the atomic charge is the same in all cases. Experiments with liquids give no direct measure of this charge, but they allow us to determine its ratio to the mass of the carrier. As that carrier in liquids is the chemical atom, it was natural to assume that it would also be so in the case of gases.

The question was finally settled by Sir J. J. THOMSON, who proved that the carrier of negative electricity had a mass much smaller than that of a chemical atom. Ultimately it was found that, near the kathode of an electric discharge through gases, it is actually the atom of negative electricity which is set free, and acts as carrier. The charge of such an atom of electricity or 'electron', as it had been called by Johnstone Stoney, secretary of Queen's Uni-

[1] G. S. Ohm, *Die galvanische Kette*, 1827.

versity, was determined by Sir Joseph Thomson and was announced at the British Association meeting of 1899. It is now considered that 'corpuscles of positive and negative electricity' are the elemental atoms from which all matter is built up.

Radio-activity

Near the end of the 19th century W. C. Röntgen of Würzburg demonstrated quite a new class of phenomena: that electric discharges in a high vacuum could generate a radiation—now known to be due to very short waves—which could penetrate many bodies opaque to ordinary light. These Röntgen rays were called X-radiation. On a particular occasion when some speaker had attributed the discovery of the X-rays to Lenard rather than to Röntgen, Stokes replied: 'Lenard may have had the rays in his brain but Röntgen got them into other people's bones.'

In 1896 Becquerel, while trying to find X-rays in sunlight, observed another effect which was found to be shared by the new element discovered by M. and Mme Curie, which was called Radium. Uranium and Thorium were found to exhibit similar radio-active properties, the most striking of which are their power of ionizing and of affecting photographic plates.

The first observations seemed impossible of explanation. Lord RUTHERFORD was the first to discover that the elements Thorium and Radium give up gases—the so-called emanations—which themselves were radio-active. These, diffusing through the air of the laboratory, had affected the instruments and led Becquerel and Curie astray.

Rutherford and Soddy showed that radio-activity is due to the ejection of corpuscles from the parent body, which thereby becomes transformed into another substance, itself subject to further decomposition through the emission of other corpuscles. The decomposition proceeds at a definite rate, and the life of any radio-active substance can, therefore, be foretold. The ejected particles consist either of one or more negative electrons (β particles) or positively charged corpuscles (α particles); frequently both are emitted. The α particle carries twice the charge of an electron, and weighs about twice as much as an atom of

hydrogen: that is to say, as much as a Helium atom. Rutherford suggested, and Ramsay proved that the two were identical. The emanation of Radium which emits an α particle was kept in an exhausted tube for several days, when the Helium line was demonstrable, though no Helium had been present originally.

This was an historic event as it supplied the first definite example of the decomposition of a chemical element.

The action of the devices (crystal detectors, &c.) first used in receivers for radio-telegraphy was explained by Sir Ambrose Fleming of St. John's College as a rectifying of the high frequency alternations. With this knowledge he designed the first form of Thermionic valve or Fleming valve which is now the essential element in wireless telegraphy and telephony, and without which there would have been no broadcasting as it exists to-day. Though no more sensitive than a good crystal as a rectifier, it has the great value of permanence of adjustment. Fleming came up to Cambridge in 1877 at the age of 27 to work with Clerk Maxwell.

ELECTRICITY AND MAGNETISM

130. **Load-stone in silver mounting.** **Early 17th. cent.**
Professor G. H. Falkiner Nuttall.

It was taken from Leeds to Dublin by Michael Falkiner in 1651–4. See p. 499. Width $2\frac{1}{5}$ inches.

131. **Chinese Geomantic Compasses.**
Archaeological Museum.

Diameters 13 inches and 6 inches. The larger one was brought home by Capt. W. Hanwell, R.N. in 1821.

132. **Magnetic Compass.** Abrahams, Bath. **c. 1790.**
Fitzwilliam Museum.

133. **Nairne's Frictional Machine.** c. 1773.
Cavendish Laboratory.

Used by Cavendish.

134. **Early Volta Pile.**
Cavendish Laboratory.

135. **Wollaston's Midget Thimble-Battery.**
Oxford Museum of History of Science.

136. Glass Punctured by Electric Spark by Ruhmkorff. 1801.

Belonged to Sir G. Stokes.

Cavendish Laboratory.

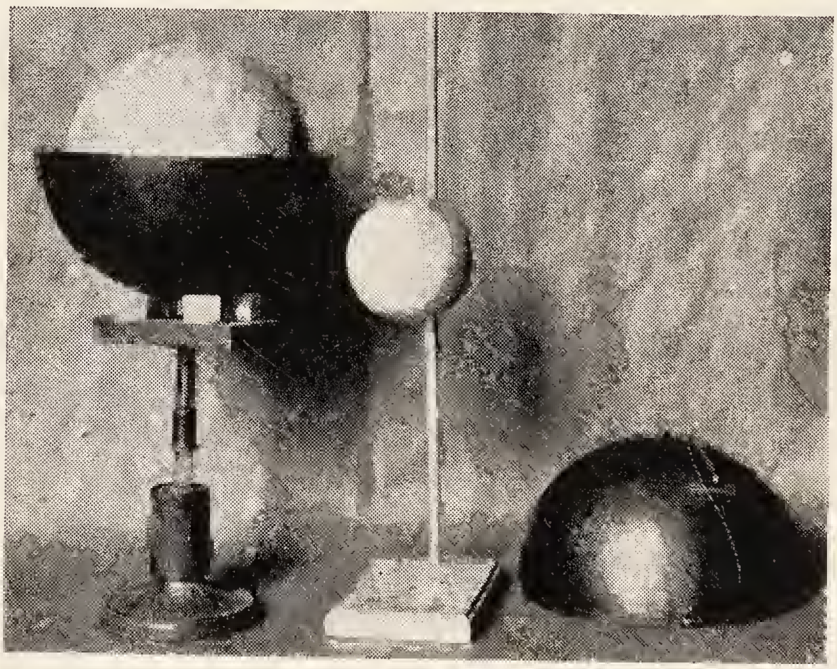
137. Maxwell's Apparatus to attempt to show the kinetic energy of an Electric Current.

Cavendish Laboratory.

A ring round which an electric current was flowing was rotated rapidly on a vertical axis around a central electromagnet carried on a horizontal axis within the ring.

Electricity and Magnetism, ii, pp. 211–21.

138. Maxwell's Apparatus to prove the Inverse Square Law.



Description in A. Gray, *Treatise on Magnetism and Electricity.*

139. Water-dropping Accumulator. Kelvin Model.

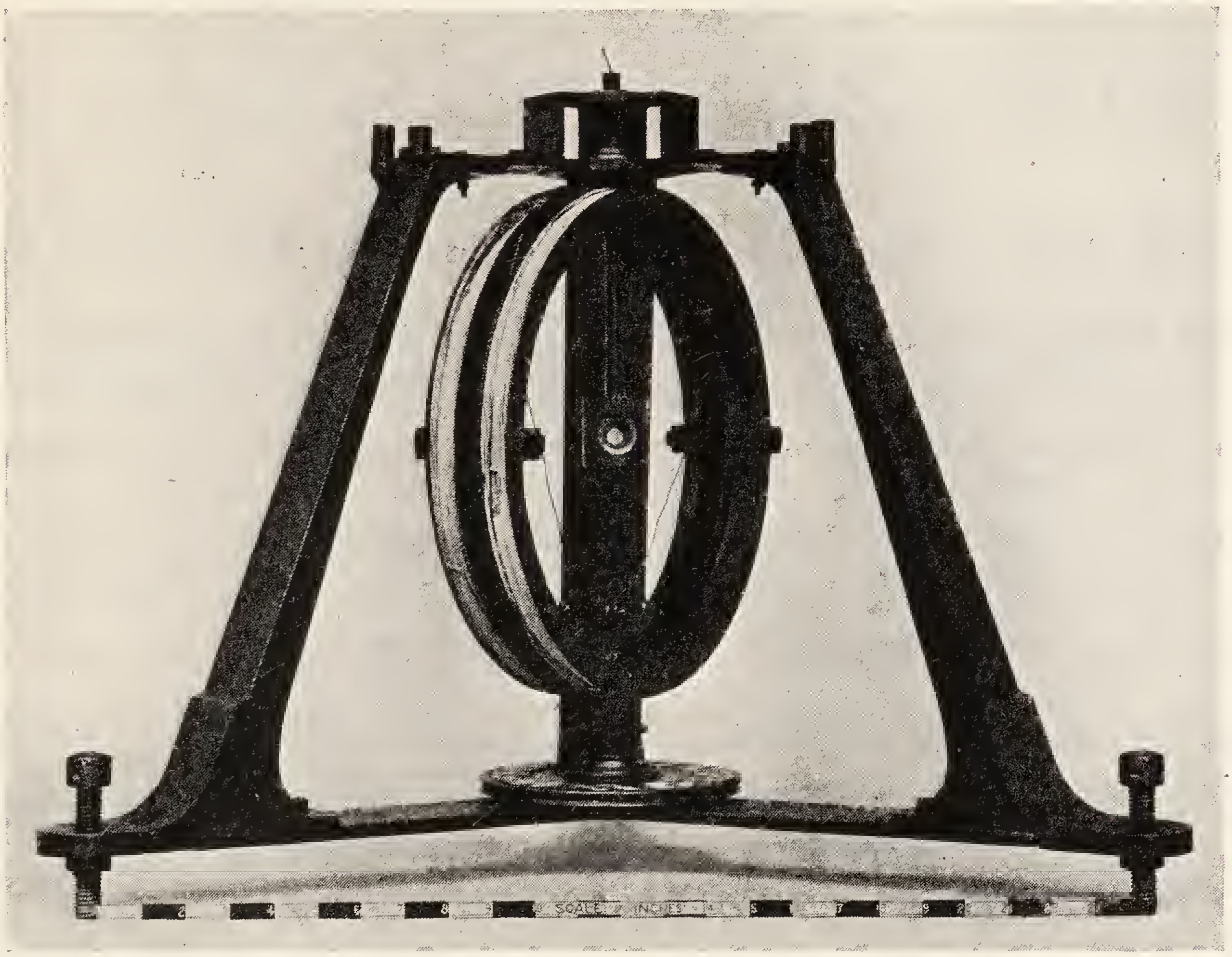
140. Maxwell's Apparatus for comparison of Electrostatic and Electromagnetic Forces.

141. Rutherford's Magnetic Detector for Electric Waves. 1896.

Cavendish Laboratory.

142. Rayleigh's Spinning Coil for the Absolute Determination of the Ohm. **1880.**

Based on Maxwell's lighter apparatus of 1863–4.



143. Thermoelectric Couple.

Cavendish Laboratory.

From Sir G. Stokes.

JACKSONIAN PROFESSORSHIP OF NATURAL EXPERIMENTAL PHILOSOPHY, 1782.

1.	ISAAC MILNER	1782
2.	FRANCIS J. H. WOLLASTON	1792
3.	WILLIAM FARISH	1813
4.	ROBERT WILLIS	1837
5.	SIR JAMES DEWAR	1875
6.	CHARLES THOMSON REES WILSON	1925
7.	EDWARD VICTOR APPLETON	1936

CAVENDISH PROFESSORSHIP OF EXPERIMENTAL PHYSICS, 1871.

1.	JAMES CLERK MAXWELL	1871
2.	JOHN WILLIAM STRUTT	1879
3.	SIR J. J. THOMSON	1884
4.	LORD RUTHERFORD	1919

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Nairne's Advertisement

(*St. John's College*).

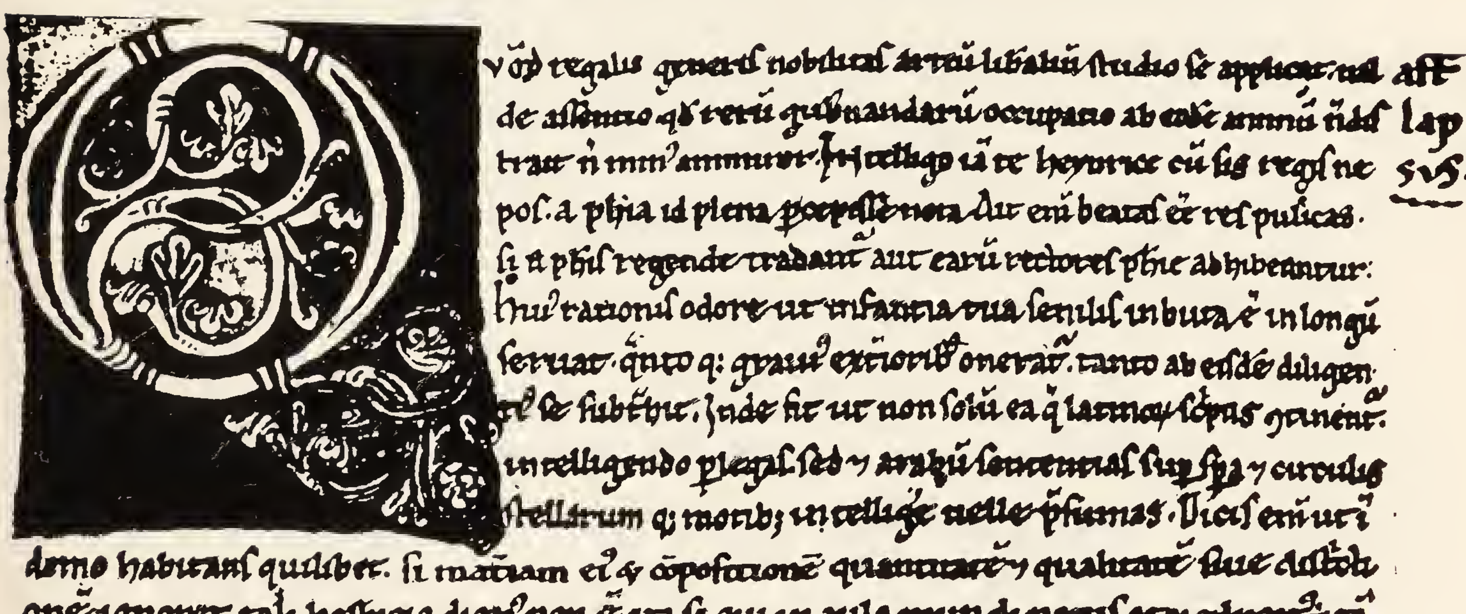
V

ASTRONOMY

Early descriptions of astronomical instruments are to be found in several manuscripts in the University libraries.

Adelard of Bath's Astrolabe. c. 1140.

The Fitzwilliam Library can boast the possession of the earliest known treatise on the Astrolabe written by an



ADELARD OF BATH, *De Operatione Astrolabii*, c. 1140.
MS. McClean 165, f. 81.

Englishman. Public attention has been drawn to it by Dr. H. C. Darby[1] of King's College. It is in a volume of astrological tracts marked McClean MS. 165, and has been dated about 1140. The preamble to this *De Operatione Astrolabii* states that the author was the celebrated

[1] H. C. Darby, *Note on an Early Treatise on the Astrolabe, Geographical Journal*, Feb. 1835.

Adelard of Bath, 'Incipit libellus magistri Alardi bathoniensis de opere astrolapsus', and, if we may judge from a mention of the meridian of Bath, it was probably written at that place. A later and shorter version of the same work is in the British Museum, Arundel MS. 377, ff. 69–74. Both this treatise and the almost contemporary work of Robert of Chester, who was a little junior to Adelard, were unknown to me before Dr. Darby drew my attention to them. Robert had actually come into direct contact with Arabian science when he lived in Spain. Unfortunately we do not know whether Adelard had enjoyed the same advantage. The character of Adelard's Astrolabe is partially indicated by four figures somewhat roughly drawn.

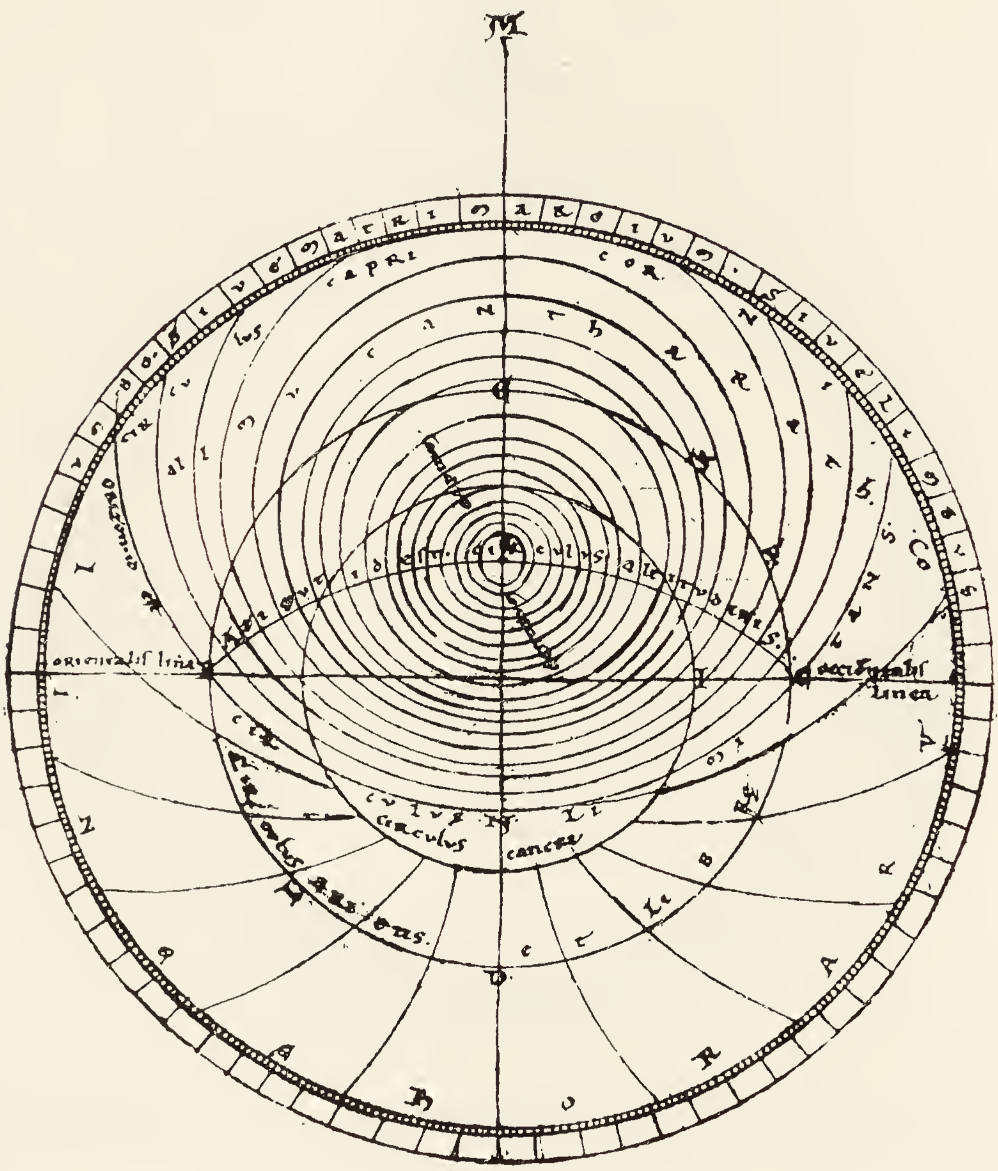
The periphery of the instrument, inscribed *Umbo sive matrimargium sive limbus,* is divided into 95 parts in each quadrant instead of the usual 90 degrees. The enclosed 'plate' for latitude 47° is engraved with a complete set of lines inscribed with their names *M[eridionalis], Orientalis linea, Occidentalis linea, Circulus Capricorni, Circulus Cancri, Circulus Arietis et Libre.* Also with 18 *Almucantharath,* one for every 5 degrees, and with the *Linie horarum.* Unfortunately the figure of the Rete is unfinished, but a table shows that it was for the following 24 stars, with Algol, Calbalagrab, and Denebalgedi mentioned in another table.

Numerus graduum declinationis stellarum astrolabicarum ab equinoctiale circulo in septentrionem vel meridiem.

Aries	Catozpatan XIIII	Virgo	Algurab X
Taurus	Alhadiph XXXV	Libra	Alrimech XVII
,,	Aldebaran XVI	,,	Benenaz XLV
Gemini	Alhaioch XLI	,,	Alramech XXV
,,	Rigel XI	Scorpio	Elfeca XXXIV
,,	Alzeuze V	,,	Alhawe XI
Cancer	Alhabor XIII	Capricornus	Wega XXXVIII
,,	Algo[me]ize VII	,,	Altair IIII
,,	Egregez XXXVI	,,	Delphin XI
Leo	Aldi[b]aran II	,,	Alriph XLV
,,	Calbalezeda XIIII	Aquarius	Alferath XXI
,,	Alrubuca XLV	Pisces	Denepcaitoz XV

A roughly graduated circular Calendar on the back shows that the 1st of Aries fell on March 12.

A second table, *Tabula Ptholomei de fixis stellis,* giving 27 *Nomina stellarum* with their *Nomina signorum, Longitudo* and *Latitudo* completes the work.

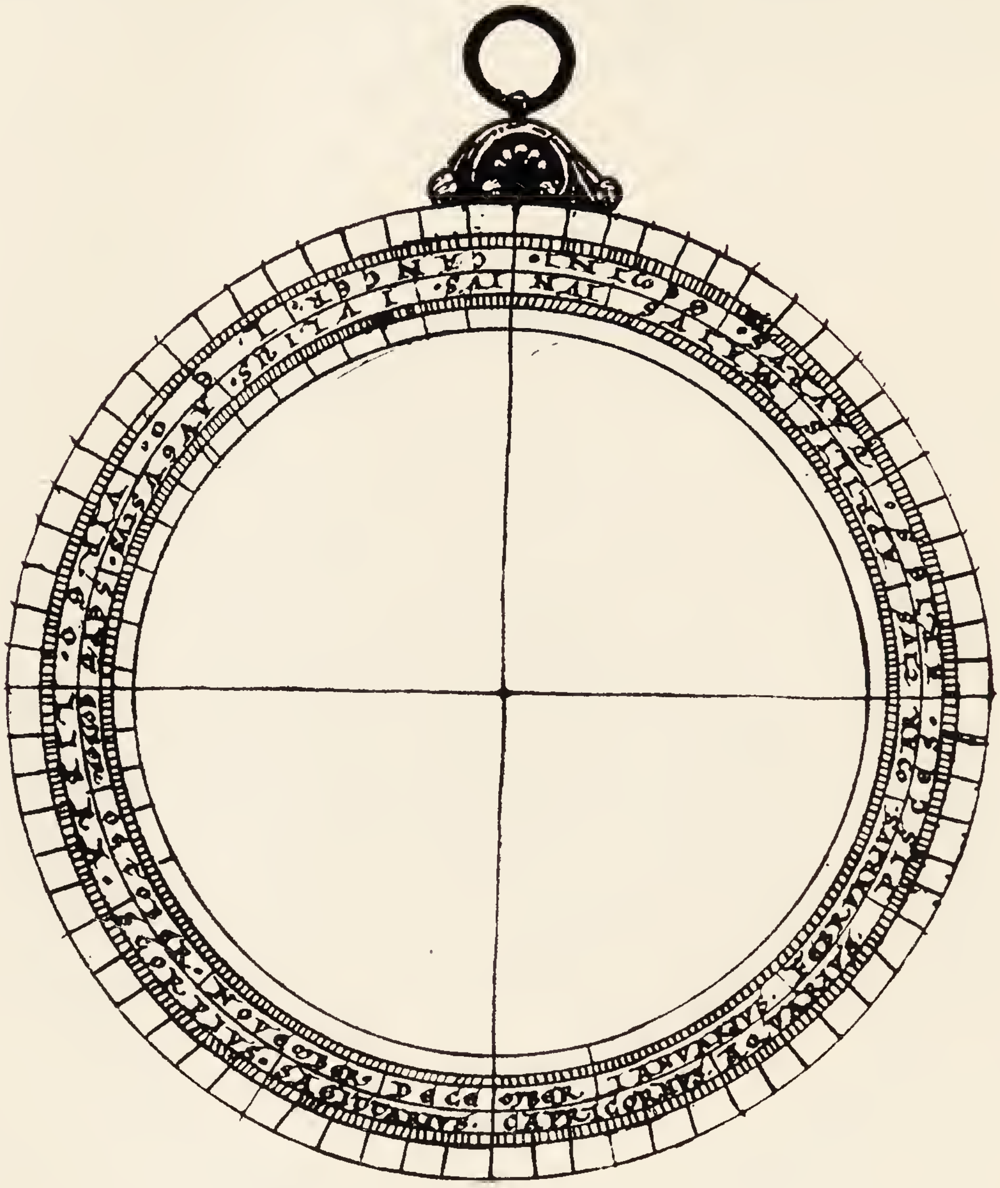


Border and Tablet of Adelard's Astrolabe
Tablet for 47° 30′.

MS. McClean 165.

Dr. Darby and others have justly doubted whether these early men of science could have used their Astrolabes for the determination of terrestrial longitudes, but it must be remembered that their asserted ability to do so may have been due to a confusion in the minds of copyists or editors of manuscripts, between the longitude of a terrestrial region and a stellar 'longitudo' as stated in the Ptolemaic

table. The text, after stating that one of the uses of the astrolabe is to measure 'the longitude or latitude of any region you please', goes on, 'you must know therefore that



Circular Calendar on back of Adelard's Astrolabe, c. 1140.

my masters have not up to the present determined the longitude of regions by any means other than by difference of the times of an eclipse'.

Messahallah's Astrolabe.

There are later drawings of astrolabes in MS. Ii. 3. 3 dated A.D. 1276 with coloured figures. And in Hh. 6. 8; Ii. 1. 13; St. John's F. 25; MS. Fitzwilliam 166, all of the 13th century. The text is usually that of Messahallah translated into Latin. Others are Kk. 1. 1; St. John's F.

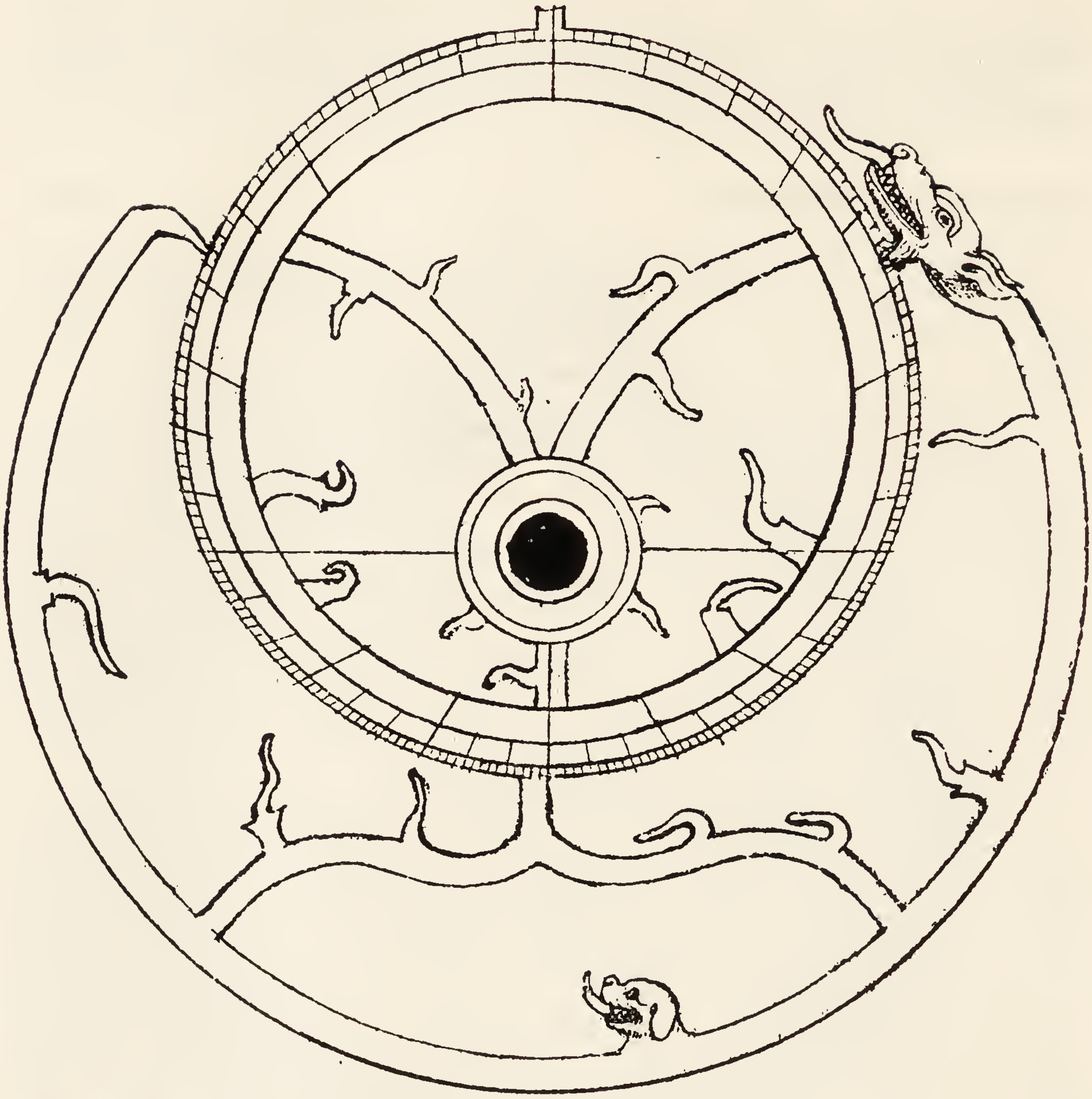
18 (15th cent.); Emmanuel 36; Peterhouse 75 (14th cent.); Caius 174 (14th cent.). Chaucer would almost certainly have been familiar with such a translation.

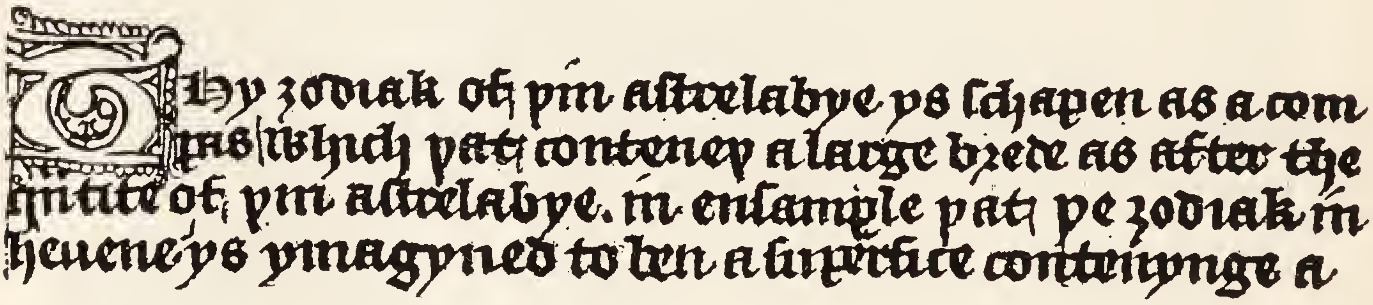
Chaucer's Astrolabe. 1391.

Although the use and construction of Chaucer's Astrolabe has been made widely known by the work of the Rev. W. W. Skeat, fellow of Christ's College, there is no example of an instrument of that type in Cambridge.

Its appearance is well shown by the figures that illustrate the Bodleian manuscript, MS. Rawlinson D. 913, one of which is again reproduced on p. 128. The fine Cambridge manuscript Dd. 3. 53 was used by Skeat as the basis for his edition of 'The Treatise on the Astrolabe addressed to his son Lowys by Geoffrey Chaucer A.D. 1391', published in 1872. Other MSS. are Dd. 12. 51; Corpus 424; Trinity R. 15. 18; St. John's E. 2.

Chaucer's Treatise has the merit of having been the first text-book written in the English language on the most important scientific instrument of the age, but the necessary explanatory figures with which it was illustrated were not published until the present decade when they were printed by the present writer from the Cambridge text, a page of which is here reproduced in facsimile. The figure chosen for illustration is placed on folio 23, and comes after section 33 'To knowe the senith of the altitude of the sonne etc.' and section 34 'To knowe sothly the degree of the longitude of the mone, or of any planete that hath no latitude for the tyme fro the Ecliptik lyne'.

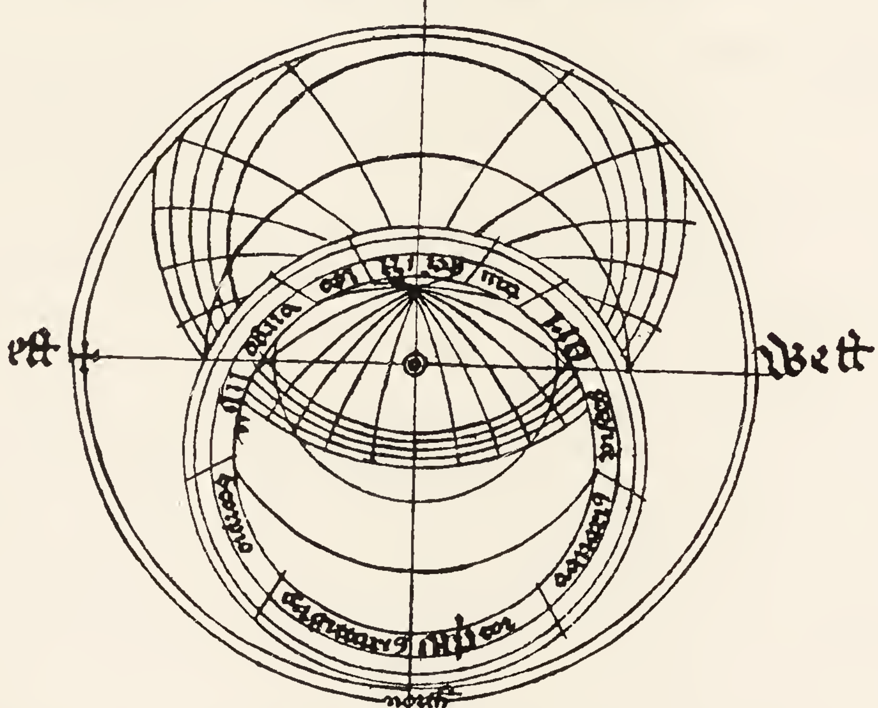



Thy zodiak of þin astrelabye ys schapen as a com
pas which þat conteneþ a large brede as after the
quantite of þin astrelabye. in ensample þat þe zodiak in
heuene ys ymagyned to ben a superfice conteynynge a

RETE OF CHAUCER'S ASTROLABE, 1391.
MS. Rawlinson D. 913.

To knowe the senyth of the altitude of the sonne &c

¶ This is no more to seyn but any tyme of the day tak the altitude of the sonne & by the azymut in which he stondith maistou sen in whiche partie of the firmament he is ¶ & the same wyse maistou sen by the nyht of any sterre whether the sterre sitte est or west or north or any partie bitwene after the name of the azimut in which is the sterre ¶ for the more declaracioun lo here the figure



To knowe sothly the degree of the longitude of the mone or of any planete that hath no latitude. and for the tyme is the Eclip tik lyne

¶ Tak the altitude of the mone & rekne thin altitude up among thyne almykanteras on which side that the mone stande & set there a prikke ¶ Tak thanne anon right up on the mones side the altitude of any sterre fix which that thow knowest & set his centre up on his altitude among thin almykanteras ther the sterre is founde ¶ Waite than which degree of the zodiak touchith the prikke of the altitude of the mone & tak ther the degree in which the mone standith ¶ this conclusioun is verrey soth yif the sterres in thin astrolabie stonden after

Chaucer's Treatise on the Astrolabe, 1391.
MS. Dd. 3. 53, f. 23, §§ 33–4.

Quadrant.

The Treatise on the Quadrant occurs in St. John's F. 25 (cent. xiii) and in Ii. 1. 17 (early xiv cent.).

Chilindre. 14th cent.

The Chilindre is figured in manuscripts Hh. 6. 8 (cent. xiii); Ii. 1. 13; Ii. 1. 15, and is described in an astronomical codex A. 229, from the Bury St. Edmunds Library, Macro MS., No. 18.

Rectangulus. 1326.

University Library MS. Ee. 3. 61.

Invented and constructed by RICHARD OF WALLINGFORD, Abbot of St. Albans.

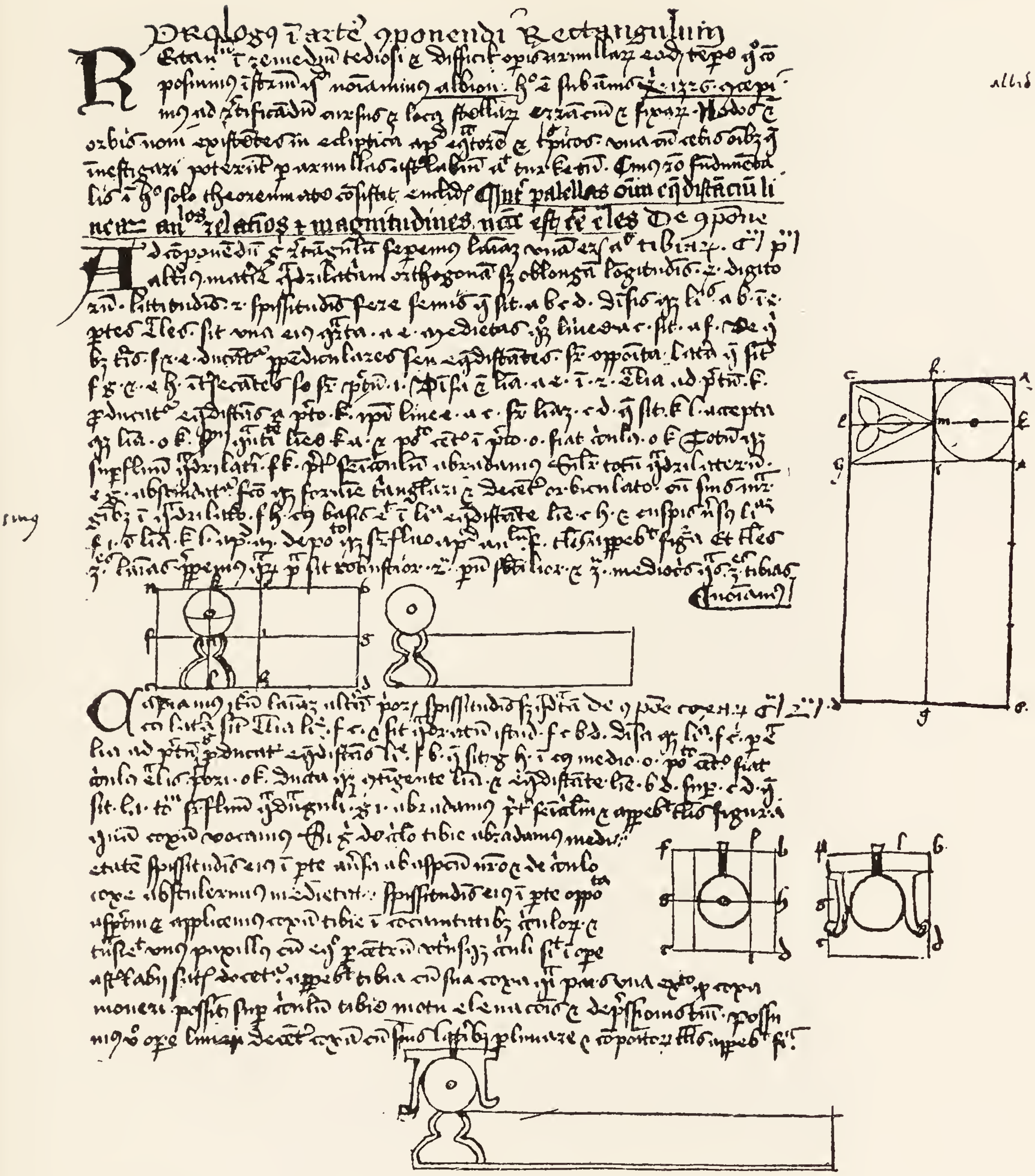
This interesting instrument was first fully described in *Early Science in Oxford*, ii, p. 32. It consisted of four brass rules hinged to one another and mounted by a swivel joint on the top of a pillar. The lowest rule (I) was engraved with a scale. The uppermost rule (IV) was provided with pin-hole sights and a plumb-line which would have reached the divided scale on rule I. Rules II and III were hinged in the manner shown in the figure and could be inclined to make any desired angle with rule I, which must have remained in a horizontal plane.

By its means three directions in space can be indicated at the same time, and the movements of a planet measured relatively to two fixed stars.

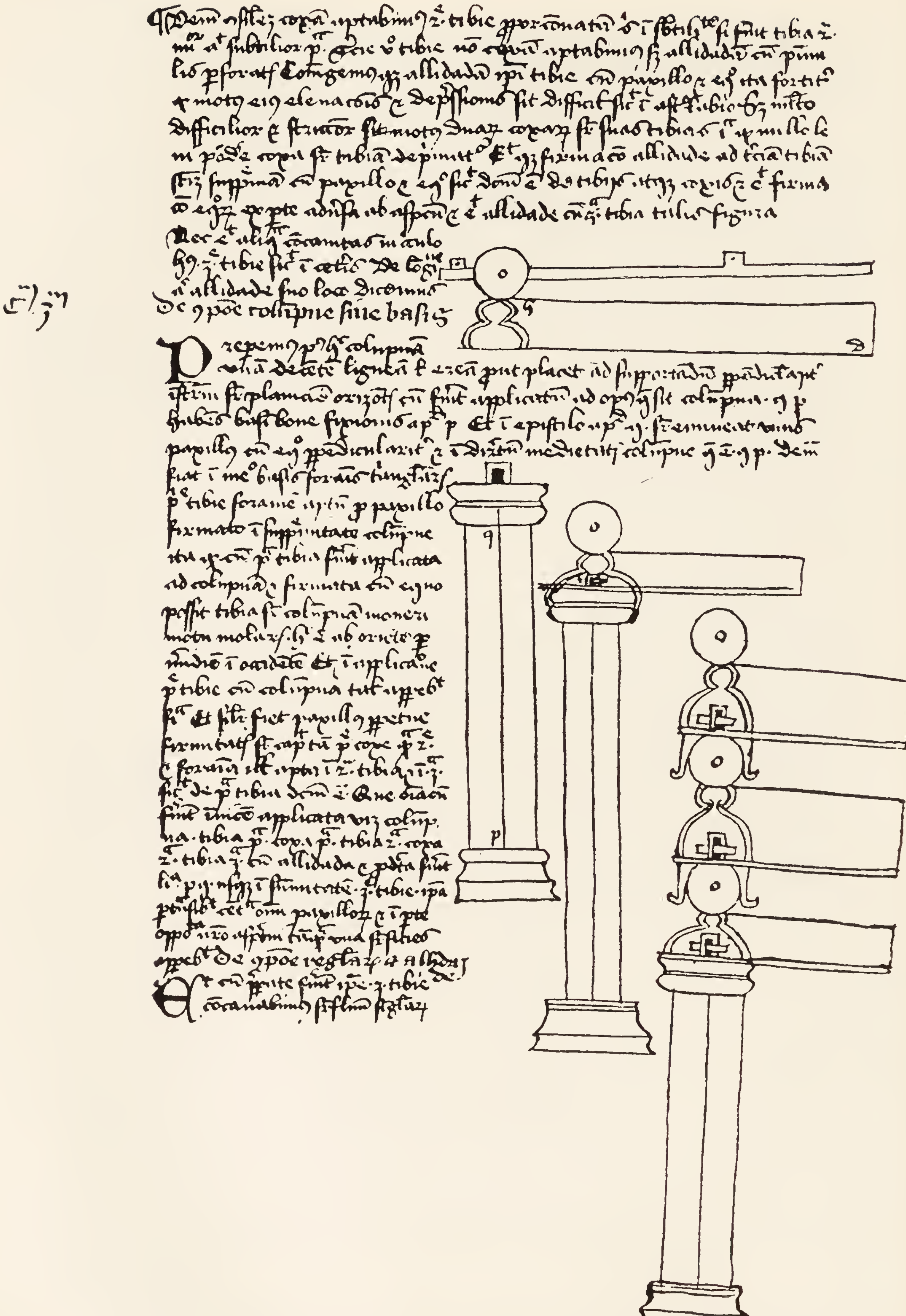
Wallingford's Rectangulus is of especial interest because it is the oldest English Astronomical Instrument known, of which the inventor has left us a sufficiently detailed account to enable us to reconstruct it after six hundred years by his method, and from his working drawings.

The various stages in which the various parts were constructed and built up are very well shown in MS. Ee. 3. 61 which contains the illustrated 'Prologus in artem componendi Rectangulum', four pages of which are here reproduced.

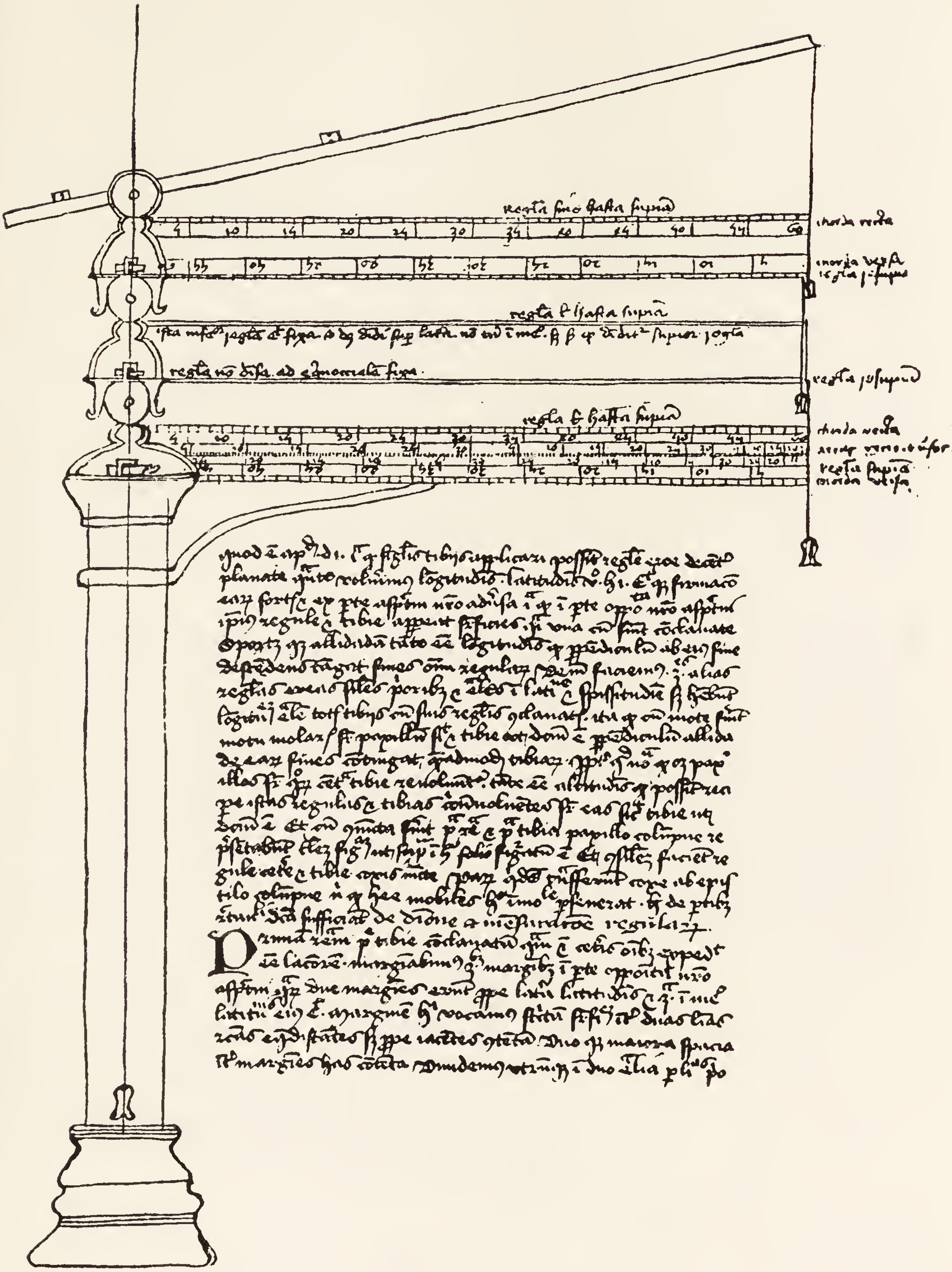
The drawing of the figures is less precise than that of those in MS. C.C.C. Oxon. 144, and the graduation of the rules is less precisely drawn. The Oxford text has been printed.



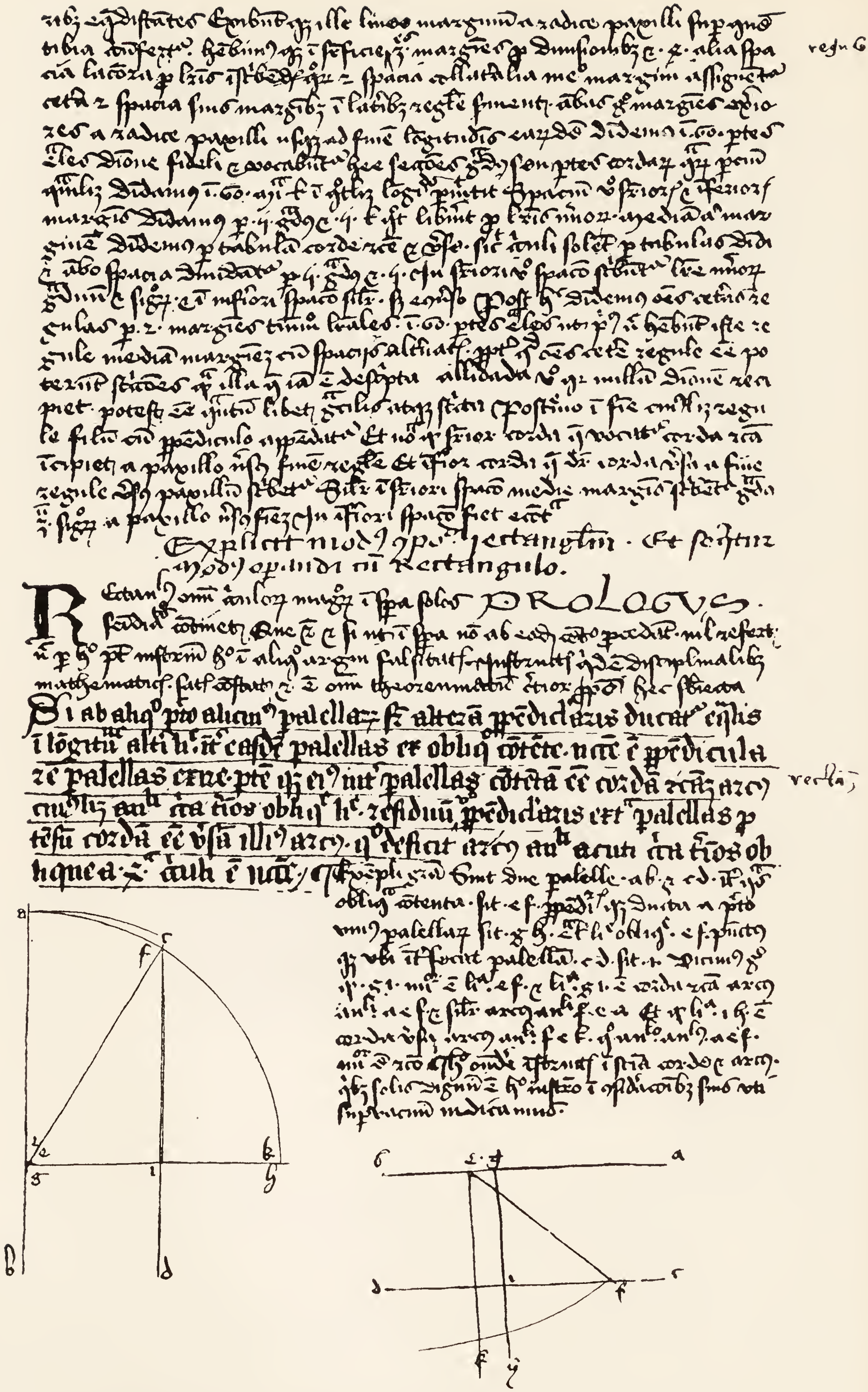
Richard of Wallingford, De arte componendi
Rectangulum, 1326.
MS. Ee. 3. 61, f. 8.



De arte componendi Rectangulum.
MS. Ee. 3. 61, f. 8 v.



De arte componendi Rectangulum.
MS. Ee. 3. 61, f. 9.



END OF THE DE ARTE COMPONENDI RECTANGULUM AND BEGINNING OF THE MODUS OPERANDI CUM RECTANGULO.
MS. Ee. 3. 61, f. 9v.

Navicula de Venetiis. **14th Century.**

University Library MS. Ee. 3. 61.

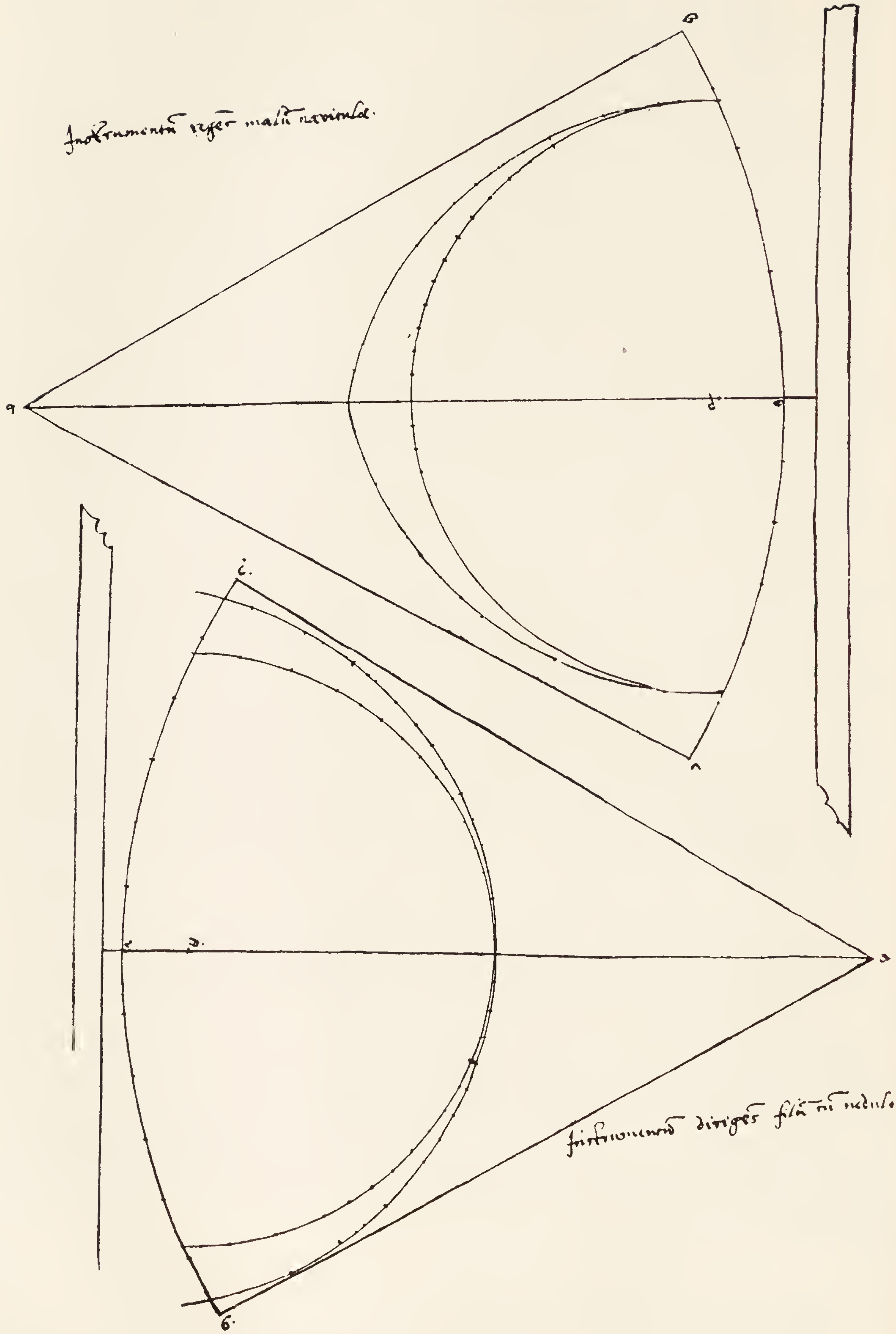
We have not succeeded in tracing any copy of the treatise '*Ad constructionem Navicule de Veneciis*' among any of the Cambridge manuscripts, but at the end of the above-quoted MS. there are the diagrams, reproduced on pp. 136–7, which have evidently been derived from the treatise. A version of the treatise has already been printed from the Bodleian MS. 68 in *Early Science in Oxford*, ii, pp. 375–9, which has different illustrations. Cambridge can now supply the figures of the three instruments, which are 'valde necessaria' for the construction of Naviculae, though the text appears to be wanting. Two figures are described as 'Instrumentum regens malum naviculae' and 'Instrumentum dirigens filum cum nodulo'.

Apparent construction: In both figures *bc* an arc of 60° of a circle of radius *ab*, has been divided into twelve arcs of five degrees each. Along mid-radius *ae*, *ed* has been measured approximately equal to a chord of five degrees. With centre *d* and radius equal to half *ae* less *de*, semicircles have been drawn and their limbs divided into five-degree spaces. Procedure then varies in the two figures. In the figure for the 'thread' a semicircle with centre *e* and radius equal to half *ae* has been drawn so as to be tangent to the inner semicircle.

In the figure for the 'mast' the outer arcs of similar radius ($= \frac{1}{2}$ *ac*) have been drawn tangentially to the inner semicircle near the points where it cuts the limiting arc *bc*.

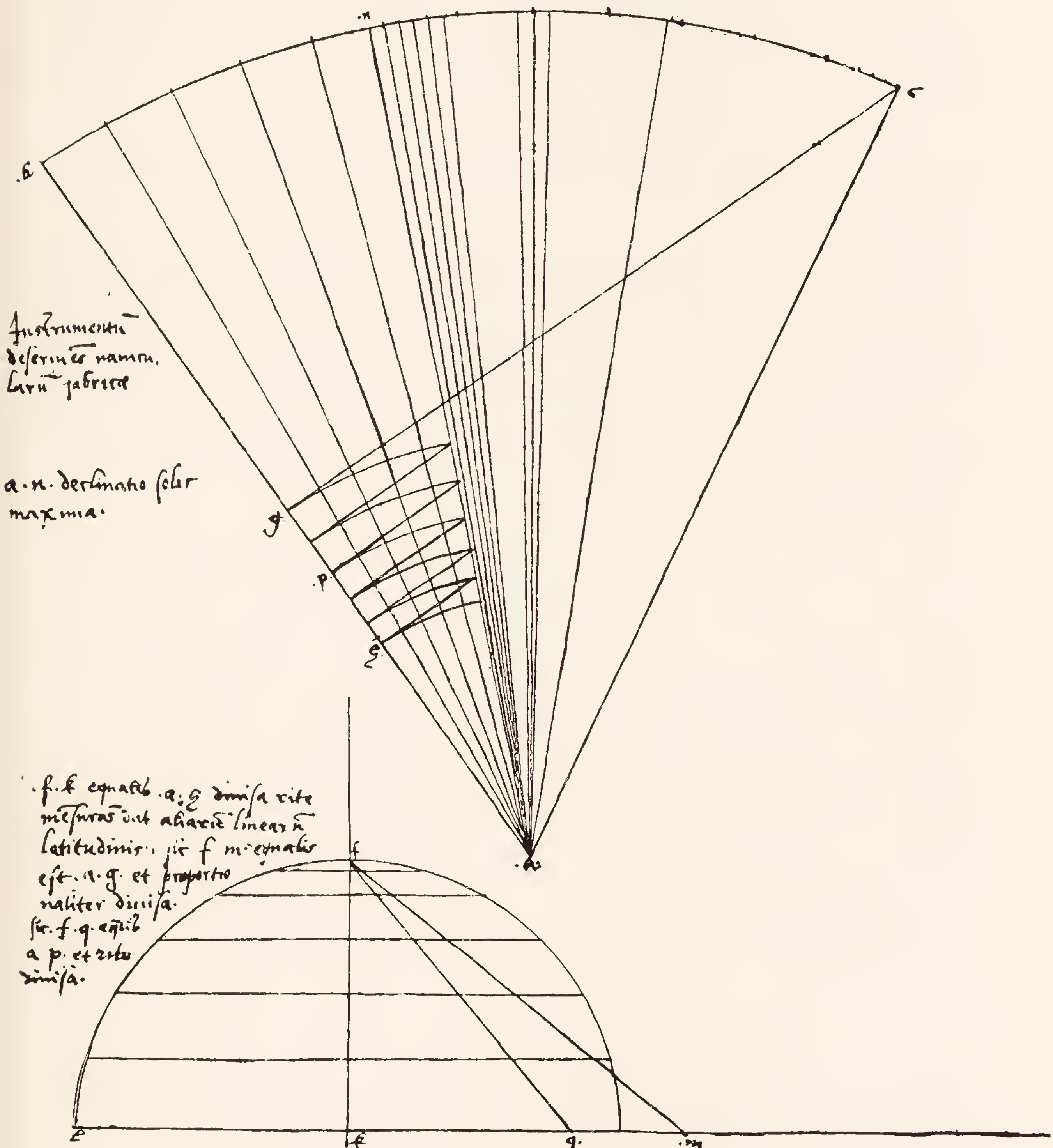
In both figures the points at which the radii of the smallest circle radiating from *d* at 5° intervals would cut the outer arcs have been marked, a procedure which would appear to have been the object of the construction.

The figure on p. 137 is a diagram of an 'Instrumentum deserviens navicularum fabricae', in which *an* is the 'declinatio solis maxima'.



Navicula de Venetiis.
MS. Ee. 3. 61.

The figure below is evidently intended to show how the projection of a hemisphere with six parallels of latitude can be used for dividing lines emanating from the pole *f* into proportional parts. The accompanying explanation reads '*fk* equalis *ah* divisa rite mensuras dat aliarum linearum latitudinis, sic *fm* equalis est *ag*, et proportionaliter divisa, sic *fg* equalis *ap* et rite divisa'.



Navicula de Venetiis.
MS. Ee. 3. 61.

Calendars and Tables.

It is a remarkable fact that Nicolaus de Lynne, if he were as East Anglian as his name suggests, and his collaborator, John Somer, when calculating tables starting from 1387 and 1367 respectively, should have adopted the meridian of Oxford for their calendars.

Although in Cambridge, as in Oxford, very few early astronomical books still remain in the possession of their original owners, it is not unreasonable to assume that the manuscripts now in the libraries, derived from most varied sources, do not under-represent the books that would have been available for reference in Cambridge in the 13th, 14th, and 15th centuries.

During the 14th century astronomers at Oxford used tables in a form that closely resembled the original Alphonsine tables that had been issued from Toledo observatory about 1272. In some respects they were improved, notably as regards the table of latitudes, and they were provided with a new preface written by William Reed of Merton College, afterwards Bishop of Chichester.

The astronomers of East Anglia of the early part of the fifteenth century appear to have derived their inspiration from these tables of William Reed, and from works by certain other astronomers of the Merton School,[1] more particularly from those of Simon Bredon and Walter Brit. Evidence on this point is supplied by an astronomical Codex, which belonged to and was partly compiled by JOHN HOLBROOK, Master of Peterhouse, 1418–36. The volume contains a copy of the Tables of William Reed and of the *Canones*, also Holbrook's *Commentary* thereon. Then followed the *Tabulae Cantabrigienses*, made at Cambridge in 1430. These tables have been described as the first advance in science made at Cambridge. In a brief but very curious preface, Holbrook mentions the *Tabulae Oxonienses* of William Reed, and points out errors in them so that his attempt may not be considered 'supervacaneum aut inutile post tabulas Oxonienses quas egregius vir Willelmus Cicestreñ antistes composuit'.

The contents of this highly interesting *Codex Holbrooki-*

[1] *Early Science in Oxford*, vol. ii.

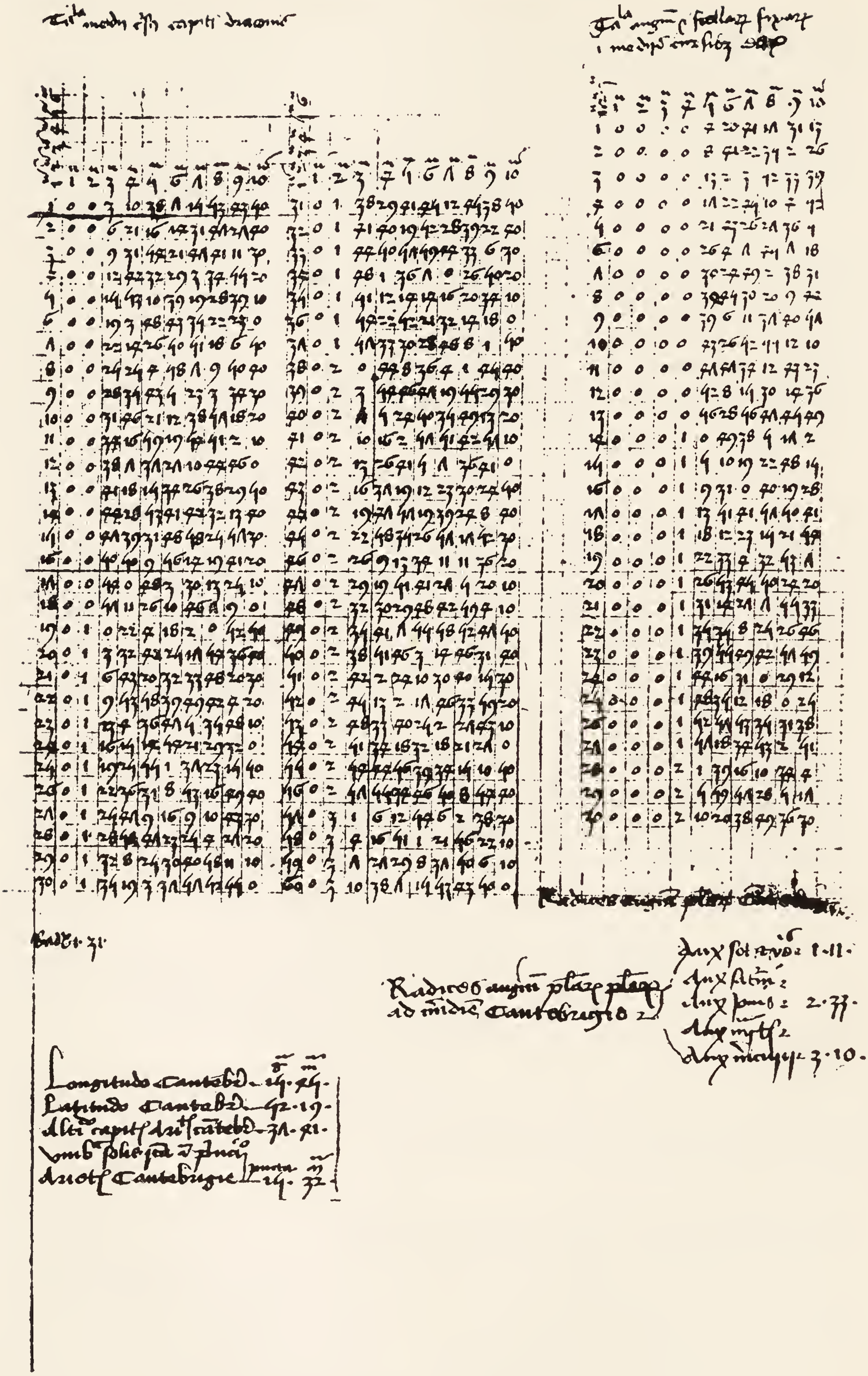
anus resemble those of the earlier Oxford codices, and are as follows:

Suchwelles *Scheme of Nativity of Henry VI* (Astrologer Royal).
Walter Britte *Theoria planetarum* inc. Circulus ecentricus et egresse.
Bredon *Tabula declinationis solis.*
Canones super tabulas cordarum et umbrarum.
Johannes de Lineriis *Tabulae.*
Holbrook's notes thereon, dated 1428.
Johannes Walter *Tabula equacionis domorum.*
Fellow of Worcester College.
C. Kyngeston Observations on the eclipse of the sun on 24 May 1517, 9 h. 57 m. made at Cambridge in the year in which he became a fellow of Peterhouse.
Radices motus octave spere ad eram Incarnationis per meridies Tholeti, Oxonie, Londonie, Colchestre, Parisius, et Cantabrigie.
The computation for Cambridge is added in Holbrook's handwriting.
Tabulae Alfonsi regis Castelle.
Holbrook *Canones super Alfonsi tabulas.*
Canones Tabularum Willelmi Reed.
Wm. Reed *Tabulae.*
Holbrook *Commentarius in tabulas precedentes.*
Tabulae Cantabrigienses by J. Holbrook.
The only copy known; MSS. in the Bodleian (MSS. Ashm. 340 and 346) contain the Preface only.
Holbrook *Novae Tabulae Cantabrigienses.*

The page of the Cambridge Tables, which is facsimiled on p. 140, exhibits the following:

Tabula medii cursus capitis draconis
Tabula augium stellarum signorum in mediis cursibus earum

	Aux Sol et Venus 1. 11
Radices augium planetarum	Aux Saturni
ad meridiem Cantebrigie	Aux Jovis 2. 33
	Aux Martis
	Aux Mercurii 3. 10



HOLBROOK'S CAMBRIDGE TABLES 1430.
MS. Ee. 3. 61.

	g	m
Longitudo Cantabrigie	15.	45
Latitudo Cantabrigie	52.	19
Altitudo capitis Arietis Cantabrigie	37.	41
Vmbra solis recta in principio	puncta	m
Arietis Cantabrigie	15	32

Holbrook's Tables for Cambridge, c. 1440, were extended and possibly revised by LEWIS CAERLYON, c. 1490, and it has been suggested that the magnificent tables in MS. Caius 668 were the work of one or the other of these two astronomers. St. John's owns MS. (B. 19) that includes Richard of Wallingford's table of lunar eclipses 'noviter facta et expansa' in 1482 by Lewis Caerlyon, who pathetically records the fact that he accomplished this task when a prisoner in the Tower—'incarceratus in turre Londoniorum'.

THE SIXTEENTH CENTURY

The great experiences of Columbus and Vasco da Gama, followed by the circumnavigation of Magellan, had afforded those demonstrations of the roundness of the Earth without which further advances in the development of astronomical science were wellnigh impossible. Seamen in their need for instruments, observations, and astronomical tables became even more exacting than the astrologers had been before them. But it was not before the close of the sixteenth century that the astronomers of Oxford and Cambridge were in a position to give any considerable help. Things moved slowly. In these days of rapid progress it is difficult to realize how slow that advance was. Copernicus (1473–1543) had advanced the clearest demonstration of the Planetary System in 1530, yet we have seen no evidence that he had any disciple in Cambridge before the time of Galileo.

Still it is something to be able to record that some members of the University interested themselves and others in the apparent movements of the stars.

One of the fellows of Queens', JOHN PONET or POYNET, *b.* in Kent c. 1514, *d.* 1556, who became Bishop of

Winchester in 1551–3, was a skilful astronomer who gave Henry VIII a dial of his own device, which showed the hour of the day, day of the month, degree of the sign, planetary hour, change of the moon, ebbing and flowing of the sea, 'with divers other things no less strange'.

ANTHONY ASCHAM after 8 years' study took the degree of M.B. in 1540 and was then presented to the vicarage of Burneston in Yorkshire. He was a noted astrologer and the author of a Herbal and the following:

A treatise of Astronomy declaring the leap year etc. Lond. 1552.

An Almanacke or prognostication made for the year of our Lord 1552.

Ditto for '1557' Lond.

His Oxford contemporary ROBERT RECORD, who took the degree of M.D. at Cambridge in 1545, was also a competent astronomer. He died in 1558 a prisoner for debt.

ANDREW PERNE, *b.* East Bilney c. 1519, fellow of St. John's 1539–40, and of Queens' c. 1540–6, Master of Peterhouse 1554–89, is known to have been a man of like interests because he bequeathed to Peterhouse his globes and all his instruments of Astronomy by will dated February 1589.

A more outstanding personality was JOHN DEE of St. John's College, *b.* London 12 July 1527, *d.* 1608. He was cousin of, and on terms of intimacy with, Dr. William Aubrey, great grandfather to John Aubrey. They lived close together, the one at Mortlake, the other at Kew, and some of their correspondence came into the possession of Ashmole, who was well acquainted with Dee's son Arthur.

He records the following events as being of the most importance in his life:

'In the years 1543, 1544, 1545, I was so vehemently bent to studie, that for those years I did inviolably keep this order:—only to sleep four hours every night; to allow to meat and drink, and some refreshing after, two hours every day; and of the other 18 hours, all, except the time of going to, and being at the divine service, was spent in my studies and learning.'

In 1546 'I was out of St. John's College chosen to be Fellow of Trinity College, at the first erection thereof by

King Henry the Eight. I was also assigned there to be the Under-Reader of the Greek tongue. . . .' In May 1547 he went to the Low Countries to confer with Gemma Frisius, Gerard Mercator, Gaspar à Mirica, Antonius Gongava, and others. On his return he brought back the first astronomer's Staff in brass that was designed by Gemma Frisius, the two great Globes made by Mercator, and the astronomer's Ring of brass devised by Gemma Frisius.

From 1547 to 1550 he was at Louvain where he gave instruction to Sir W. Pickering in the use of the aforesaid three instruments and of the astrolabe. All these instruments he subsequently left to Trinity College.

On 20 July 1550 we find him lecturing on Euclid in Rhemes College, and on 15 Jan. 1556 he presented to Queen Mary a supplication for the recovery and preservation of ancient writers and monuments. He pointed out the loss to learning due to the dispersal of MSS. from monastic establishments, and prayed her majesty to take immediate steps to recover as much as possible from the wreck, whereby a magnificent national library might be formed at a trifling cost. We regret to say that the effort was fruitless. On the accession of Queen Elizabeth he computed an astrologically fit day for the coronation.

In 1564 he went abroad to present the *Monas Hieroglyphica* to the emperor Maximilian.

On returning from Lorraine in 1571 he became ill, whereupon the Queen was graciously pleased to send him her physicians, Atslowe and Balthrop, and directed Lady Sidney to comfort him with 'very pithy speeches' and 'with diverse rarities to eat'.

In 1571 the New star appeared, and Dee's astronomical knowledge was spoken of with respect by Camden. Three years later the Queen proposed to visit him at Mortlake and see his library; but hearing that his wife had only died but a few hours before, she would not enter the house. He did, however, exhibit to her his famous magic glass.

In 1577 the comet filled the people with alarm, and the Queen sent for Dr. Dee to Windsor, where he lectured her for three days, and she promised to protect him on account of his rare studies and philosophical exercises.

In 1580 Dr. Dee drew up a hydrographical and geo-

graphical description of the countries belonging to the Queen in two large rolls, which he delivered to her on 3 Oct. 1580 at Richmond. At about the same time he was engaged on reforming the Julian Calendar, and he also pretended to have interviews with angelic beings, thus spreading his fame as a sorcerer, which, however, finally dragged him down to the lowest depths of degradation. One day when engaged in prayer, the great angel Uriel gave him a convex crystal by which he could hold converse with beings of another sphere.

But as he could never recollect the conversation of the angels, he engaged one Edward Kelly as his seer, whose duty it was to gaze and describe what he saw in the crystal while Dee wrote it down. Long afterwards the minutes were printed by Dr. Meric Casaubon, forming a large folio volume of the most arrant nonsense that has ever proceeded from the press.

In 1583 Albert Laski of Bohemia visited him, and Dee, Kelly, and Laski on 21 Sept. embarked for Holland. They travelled until 1585, when a Francis Pucci was admitted to their society, but was expelled after a year; and in 1586 Dee was ordered to quit the emperor's dominions. During his absence a mob broke into his house at Mortlake and destroyed a great part of his furniture, books, chemical apparatus which had cost him £200, and a fine quadrant of Chancellor's, which had cost £30.

On 15 April 1587 there had been a little quarrel with Kelly, who went on strike, so Dee instructed his son Arthur in the use of the magic stone, but Arthur could not see anything but marks and specks. When Kelly was reinstated, Madimi, Il Il and Uriel immediately reappeared.

A little later Kelly and Dee separated for good, the former dying in 1595. In 1589 Dee returned to his Mortlake laboratory, and succeeded in recovering three-quarters of his library; but his circumstances got worse and worse. The Queen, to whom in 1588 he had written a letter of congratulation on the result of the Armada, remembered him and appointed him to the Wardenship of Christ's College in Manchester, now known as Chetham's Hospital and Library. This foundation derives from a College of Priests founded about 1422 by Thomas La Warr. It was

dissolved in 1547, but re-established in 1578 under a new charter from Elizabeth as Christ's College.

Sir W. Raleigh is said to have visited the newly appointed Warden there. The old man, 'tall and slender with a long beard as white as milk', did not find the post congenial. What with his magic glass, his holy stone given him by an Angel, and the great many stills he kept going, he disturbed the Fellows' suspicion as much as he did their tempers by his strange behaviour. Their turbulence proved too much for him and he returned to Mortlake in 1604 where he died in poverty over 80 years of age in 1608.

Dee's 'scientific' writings include the following. His non-scientific writings are indicated by the numerals omitted.

1. *Art of Logick. MS. 1547.*
3. *Prolegomena et dictata Parisiensia in Euclidis Elementorum Geometricorum librum primum et secundum in Collegio Rhemensi. MS. 1550.*
4. *Mercurius coelestis lib. 24.* MS. written at Louvain. *1550.*
5. *De usu Globi Coelestis: ad Regem Edoardum Sextum 1550. MS.*
6. *De nubium, solis, lunae, ac reliquorum planetarum, immo ipsius stelliferi coeli, ab infimo terrae centro, distantiis, mutuisque intervallis et eorundem omnium magnitudine. 1551.* Dedic. to Edward VI.
7. *Aphorismi Astrologici 300. Anno 1553. MS.*
8. *The Astronomicall & Logisticall rules and Canons, to calculate the Ephemerides by, and other necessary Accounts of heavenly motions: written at the request, and for the use of that excellent Mechanicien Master Richard Chancelor, at his last voyage into Moschovia. 1553.*
9. *The Philosophicall and Poeticall Originall occasions of the Configurations, and names of the heavenly Asterismes,* written at the request of the Dutchess of Northumberland. *1553. MS.*
10. *The True cause, and account (not vulgar) of Floods and Ebbs:* written at the request of the Rt. Hon. Lady, Lady Jane Dutchesse of Northumberland. *1553. MS.*
11. *De Acribologia Mathematica: opus magnum lib. 16. Anno 1555. MS.*

12. *Inventum mechanicum paradoxum de nova ratione delineandi circumferentiam circularem; unde valde rara alia dependent inventa lib. i. 1556. MS.*
13. *A Supplication to Queen Mary for the recovery and preservation of ancient Writers and Monuments.* In Hearne's *Johannes Glastoniensis, 490.* Reprinted in Chetham Miscellanies, *i. 46.* Cf. Cotton, Vitell. C. *vii. 310.*
14. *Articles concerning the recovery and preservation of ancient monuments and old excellent Writers, etc.* In Hearne's *Johannes Glastoniensis, 493.*
15. *De speculis comburendibus libri 6. 1557.* MS. Cotton Vitell. C. *vii. 279.*
16. *De annuli Astronomici multiplici usu lib. 2. 1557. MS.*
17. *Speculum unitatis, sive Apologia pro fratre Rogero Bachone Anglo. 1557. MS.*
18. *De perspectivâ illâ, quâ peritissimi utuntur Pictores. 1557. MS.*
19. *Epistola praefixa Ephemeribus Joannis Feldi. 1557.*
20. *Trochilica inventa mea lib. 2. 1558. MS.*
21. *Περὶ ἀναβιβασμῶν θεολογικῶν lib. 3. 1558. MS.*
22. *Προπαιδευματα Αφοριστικα Ioannis Dee Londinensis* Lond. *4to 1558 and 1568.*
23. *De tertiâ et praecipuâ Perspectivae parte, quae de radiorum fractione tractat, libris tribus demonstrati. 1559. MS.*
24. *De itinere subterraneo lib 2. Anno 1560. MS.*
25. *De triangulorum areis lib 3. demonstratis: ad excellentissimum Mathematicum Petrum Nonium conscriptis. 1560. MS.*
26. *Cabbalae Hebraicae compendiora tabella. 1562. MS.*
27. *Monas Hieroglyphica etc.* Antwerp 1564, 1584; Frankfort *1591. Repr. in Theatrum Chemicum.* English transl. by Th. Tymme *M.D.* Cf. MS. Ashmole 1440 art. 15–17; 1459 iii art. 3–6; 1819 art. 15.
28. *Reipublicae Britannicae Synopsis. 1565. MS.*
29. *De Trigono, circinoque analogico, Opusculum Mathematicum et Mechanicum lib. 4. 1565.* MS. Cotton Vitell. C. vii. 4.
30. *Testamentum Joh. Dee Philosophi Summi ad Joh. Gwynn transmissum 1568.* MS. Ashm. *1442.* Printed in Ashm. Theatrum Chemicum 334.

33. *A fruitfull Praeface, specifying the chiefe Mathematicall Sciences, what they are and whereunto commodious: where also, are disclosed certaine new Secrets Mathematicall & Mechanicall, untill these our daies greatly missed.* Before H. Billingsley's translation of Euclid's Elements, *1570.*

After the 10th book of this edition of Euclid there are many annotations and inventions of Dr. Dee.

34. *Hipparchus redivivus, tractatulus. 1573. MS.*
35. *De stella admiranda in Cassiopeiae Asterismo etc. MS. 1573.*
36. *Parallacticae Commentationes. 1573.*
37. *Hieroglyphical & Philosophical blason of the crest . . . to my antient armes. 1574. MS.*
38. *Ad Guil. Camdenum epistola prolixa. 'Mortlake 7. Aug. 1574'.* MS. Ashm. 1788.
39. *An account of the manner in which a certayn Copper-smith in the land of Moores, and a certayn Moore transmuted silver into gold.* 12 March 1576. MS. Ashm. 1394, *iii.* 1.
40. *The British Complement of the perfect art of Navigation. A great book in which are contained our Queen Elizabeth her tables gubernautick for longitudes and latitudes finding most easily and speedily, yea, if need be, without sight of sun, moon or starr: with many other new and needfull inventions gubernautick. 1576. MS.*
41. *The great Volume of famous and rich discoveries; wherein also is the History of King Solomon. . . . 1576. MS.*
42. *General and Rare Memorials pertayning to the perfect Arte of Navigation: Annexed to the Paradoxal Cumpas in Playne: now first published 24 years after ye first Invention thereof.* Lond. fol. 1577 (*anon*). Dedicated to Christopher Hatton. See MS. Ashm. *1789, iv.*

Partly reprinted in Chetham's *Miscellanies, vol. i.*

43. *Her Majestie's title Royal to many foreign countreys, kingdomes and provinces, in 12 vellum skins of parchment, fair written for her Majestie's use. MS. Cf.* MS. Cotton Vitell. *C. vii. 3.*
45. *Additions to Robert Record's* Ground of Artes. Lond. *8vo. 1579, 1582, 1590.*
46. *Atlantidis, vulgariter Indiae Occidentalis nominatae, descriptio. 1580. MS.*

47. *Navigationis ad Cathayam per septentrionalia Scythiae et Tartariae littora delineatio Hydrographica. 1580.* MS. Lansd. *122, art. 5.*
48. *Map of the Northern Hemisphere, including all America north of the line.* MS. Cotton Aug. *i, vol. i. 1.*
49. *De modo Evangelii Jesu Christi publicandi. . . . 1581 MS.*
50. *A playne discourse and humble advise, for our gratious Queene Elizabeth her most excellent Ma^tie^ to peruse and consider: as concerning the needfull Reformation of the Vulgar Kalender, for the civile yeres and daies accompting or verifyeing according to the tyme truely spent. 1582.* MS. Ashmole 179, *vii; 1789 i.*
51. *Hemisphaerii Borealis Geographica atque Hydrographica descriptio; longe e chartis vulgatis diversa. 1583. MS.*
52. *Calendar for the Annus Reformationis 1583 (May–Dec.), showing how the eleven days of excess should be cut off, the principal feasts, the places of the ☉ and ☽, the Roman reckoning etc.* MS. Ashm. *1789, iii.*
53. *. . . ancient British Histories examined. 1583. MS.*
54. *Praefatio.*
55. *Accounts of the Household Expenses and other memoranda, from 22 Jan. 1589, to 11 Oct. 1591.* MS. Ash. 337, *iii. 2.*
56. *A triple Almanack and Prognostication for the year MDXCI. 4to.*
57. *De hominis corpore, spiritu et anima, libellus 1591. MS.*
58. *The compendious rehearsal of John Dee his dutifull declaration and proofe of the course and race of his studious life for the space of halfe an hundred years, . . . exhibited to her most gracious Majestie at Hampton Court. A. 1592, Nov. 9.*

    In Hearne *Johannis Glastoniensis 497–551;* repr. in Chetham's *Misc.*; Ashmole's transcript in MS. Ash. *1788.*
59. *Θαλαττοκρατια Βρεττανικη 20 Sept. 1597.* MS. Harl. *249, art. 13.*
60. *Dr. Dee's Apology, sent to the Archbishop of Canterbury 1594/5.*
61. *Petition to the King. Anno 1604.*
62. *A True and Faithful Relation of what passed for many Yeers between Dr. J. Dee and Some Spirits. . . .* Meric Casaubon *D.D. Lond. 1659.*

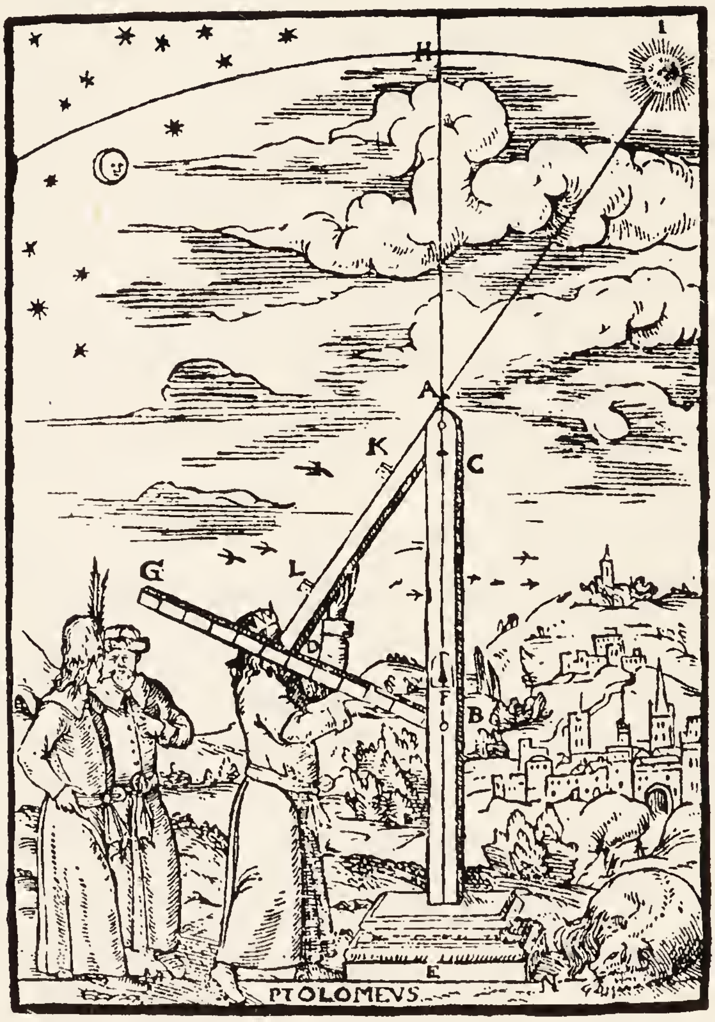
63. *The Private Diary of Dr. John Dee,* and the *catalogue of his library of MSS.* in the Ashmolean Museum at Oxford and Trinity College Library, Cambridge. Ed. by J. O. Halliwell F.R.S. Pr. for Camden Society 1842.
64. *Epilogismus Calculi diurnus Planetarum tum longitudinis tum latitudinis.* MS. Harl. *532, art. 14.*
65. *Regulae Astrologiae.* MS. Addit. *435.*
66. *Treatise of the Rosie Crucian Secrets, their excellent Method of making Medicines of Metals; also their Laws & Mysteries.* MS. Harl. *6485.*
69. *Account of an apparition to discover hid money.* MS. Addit. *3677,* art. *3.*
70. *Alchemical Collections.* MS. Ashm. *1486 v.;* MS. Addit. *2128, 2325,* art. *1–8; 2327.*
71. *Figures set on horary questions.* MS. Ashm. *337, ii. 4.*
73. *A table of the latitude, longitude, distance, and bearing from London, difference in the change of the moon and length of the longest day of places in all parts of the world.* MS. Ash. *174, art. 76.*
75. *Super nativitatem D. Edouardi Kelei (1 Aug. 1555 Wigorniae nati) Johannis Dee horoscopus.* MS. Ash. *1788, art. 11.* Pr. in Ashmole *Theatrum Chemicum 479.*
77. *His own pedigree. Cotton Cart. Antiq. xiv 1. Herein he makes himself out to be cousin to queen Elizabeth.*
79. *Letters in Latin and English.*

William Cuningham, *b.* c. 1531; Pensioner C.C.C. 1548; M.B. after 7 years study 1557; resident in Norwich 1556–9 was in 1563 appointed public lecturer at Surgeon's Hall, London. He used instruments which were similar to those of his contemporary Robert Recorde.

1. *A Newe Almanacke and Prognostication for ye yere of our Lord MDLVIII wherein is expressed the change and ful of the Mone, with their Quarters. The variety of the ayre, and also of the windes throughout the whole yeare, with infortunate times to bie and sell, take medicine, sowe plant and journey etc. Made for the Meridian of Norwich and Pole Arckticke iii degrees and serving for all England.* By William Kenningham, Physician. Lond. *8vo. 1558.*
2. *An Almanack, Licensed to John Day, 1559.*

3. *The Cosmographicall Glasse conteinyng the pleasant Principles of Cosmographie, Geographie, Hydrographie, or Navigation.* Lond. *fo. 1559*. Dedication to lord Robert Dudley K.G. dated Norwich *18 July 1559*.

A learned work remarkable for the beauty of the print and ornament. We reproduce his figure of Ptolemy's Rules or Triquetrum, from a wood-block believed to be of his own engraving. (Oldys's *British Librarian*, 26–33.)



It is made of 3. peaces, beyng 4. ſquare: As in the Picture where A. F. is the firſt peace or rule.
A.D. The ſeconde.
G.D. the third rule.
E. The Foote of the ſtaffe.
C.F. The Plumrule.
C.B. The ioyntes, in which the ſecond & third Rulers are moued.
K.L. The ſighte holes.
I. The Sonne.
H. The Zenit, or verticall pointe.
M. N. The Noone-ſtead Lyne.

4. *An invective epistle in defence of astrologers.* Frequently quoted in Fulke's *Antiprognosticon contra inutiles astrologorum praedictiones* (1560).
5. *A new almanack and prognostication, serving for the year of Christ our Lorde MDLXVI diligently calculated for the longitude of London and pole articke of the same.* Lond. 8vo. 1566.
6. *Abacus or Book of Longitudes and Latitudes of various places.* MS. Cai. Coll. 226. 'Merely a part of the *Cosmographicall Glasse.*'

Six other works are mentioned herein but were probably never printed. Their titles were:

An Apology. A new Quadrat, by no man ever publish'd. The Astronomical Ring. Organographia. Gazophilacion Astronomicum. Chronographia.

Later Calendars were compiled by WILLIAM MOUNT, 1542–1602, the botanist of King's, to whom is ascribed *A shorte declaration of the meaning and use of a perpetuall Calendare or almanack*, 1583, by W. M., in eleven chapters, with dedicatory preface to Sir Thomas Bromley, Lord Chancellor, whose chaplain the writer was. The work is illustrated by coloured tables and diagrams. Three of the latter include the arms of the universities of Oxford and Cambridge and of Queen Margaret of Anjou, foundress of Queens' College.

ABRAHAM FLEMING, who matriculated at Peterhouse in 1570, translated a work from the Latin on the Comet of 10 Nov. 1577. His titles ran: *Of all Blasing Starrs in generall, as well Supernaturall as Naturall* and *A bright Burning Beacon* &c. [1580].

'T.T.', possibly TH. TURSWELL of King's, lic. chirurg. phys., wrote on the same subject: *A View of certain wonderfull Effects of late Dayes come to passe; and now newly conferred with the Presignification of the Comete or Blasing Star which appeared in the South west, upon the 10 day of Novemb. last past. Written by* T.T. *this 28 Nov.* 1578. Lond. 1578. Turswell died in 1584–5.

JOHN MAPLET of Queens' 1560, fellow of Catharine Hall Aug. 1564, and fellow of Caius 1566–7, published an Astrological work, *The Diall of Destiny*, in 1581.

WILLIAM GILBERT of St. John's 1558, whose great work *De Magnete*, 1600, has been described, is given credit for the invention of two instruments to enable seamen to find out latitude without seeing sun, moon, or stars. They are described by THOMAS BLUNDEVILE in his *The Theoriques of the planets*, &c., 1602. Blundevile, who was an East Anglian of Newton Flotman, co. Norfolk, but not certainly of Cambridge, was well known for his popular textbook on navigation, known as *Blundeville His Exercises*, 1594.

RICHARD HARVEY, matric. Pembroke Hall 1575, fellow, was a proficient in judicial astrology. *d.* 1631.

Mercurius, sive lachrymae in obitum D. Thomas Smith. At the end of Gabriel Harvey's Smithers.

An Astrological Discourse upon the great and notable conjunction of the two superiour Planets, Saturne and Jupiter which shall happen the 28th day of April 1583.

Leap Yeare. A Compendious Prognostication for 1584. 16mo.

ROBERT WESTHAWE, B.A., of Trinity Coll. 1580–1.

An Almanacke & Prognostication made for the yeare of our Lord God 1595, calculated according to art for the Meridian for Norfolke ed. Long. 20° 0′, Lat. 52° 46′. Lond. 8vo 1595.

JOHN RACSTER, Westminster School and Trinity 1584, fellow 1591–2, incorporated at Oxford 1594. Author of *A Booke of the seven planets or seven wandering motiues of William Alabasters wit, Retrograded and remoued by John Racster.* Lond. 1598. Dedicated to the Earl of Essex. 'The same schoole bred us both, the same Universitie nourced us both, the same colledge maintained us both, . . . the same roof, nay the same bed, sometimes contained us both.'

ROBERT WATSON, Queens' 1581, lic. 1589.

1. *A new Almanack for 1595.* Lond. 1595. The last issue appeared in 1605.
2. *A new almanacke and prognostication for the yeere of our Lord MDXCVIII.*
3. *A doble Almanack or Kalender drawn for this present yeere* 1600.

THOMAS FALE, matric. Caius 1578, of C.C.C. 1583, had a licence to practise physick in 1604. He was author of the first English work on Dialling. *Horologiographica, the Art of Dialling, teaching an easie and perfect way to make all sorts of dials on any plaine plat, howsoever placed, with the drawing of the twelve signes, and houres unequall in them all.* 1593; subsequent editions appeared in 1626 and 1652. It was a translation of the work of Witikind which acted as an incentive to people of all conditions to erect instruments that would tell the time.

HOROLOGIOGRAPHIA.

The Art of Dialling:

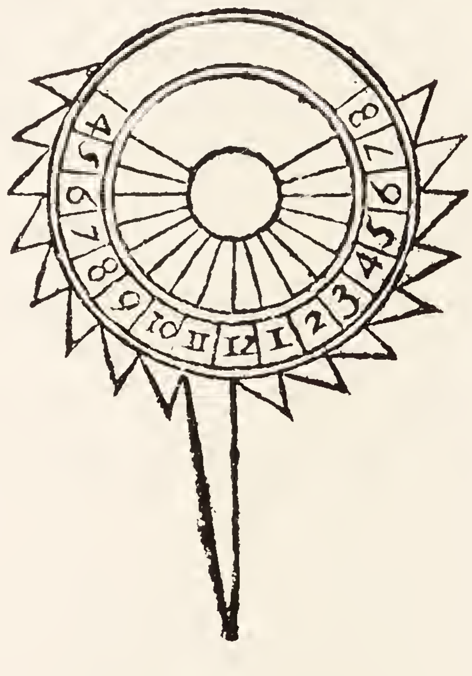
teaching an easie and perfect way
to make all kinds of Dials vpon any
plaine plat howsoeuer placed:

VVith the drawing of the twelue Signes, and
houres vnequall in them all.

Whereunto is annexed the making and vse of other Dials and Instruments, whereby the houre of the day and night is knowne:

Of speciall vse and delight not onely for Students of the Arts Mathematicall, but also for diuers Artificers, Architects, Surueyours of buildings, free-Masons, Saylors, and others.

By T. Fale.



AT LONDON
Printed by *Thomas Orwin*, dwelling in Pater noster-Row against the signe of the Checker. 1593.

Seventeenth-Century Astronomy

The opening years of the seventeenth century witnessed a widespread desire for more thorough instruction in the principles of astronomy—and the appointment of a Cambridge man to fill the Savilian Chair of astronomy at Oxford will be mentioned shortly. Even for the projected University of Ripon it was proposed on 4 July 1604[1] that in addition to a professor and two readers of physicke, there should be readers in the principles of astronomy, in spherical motions, two in planetary motions, and one in optics.

But the editors of astrological Almanacks still held on, even as Old Moore does at the present day. Among these may be reckoned:

John Searle (Emmanuel 1599), chirurgeon 1607, author of *An Ephemeris for the year 1609 to 1617; whereunto is annexed three succinct treatises: of the use of an ephemeris; of the fixed starrs; foure sections of astrologie.* Lond. 4to.

Some believed in the influence of the stars, some did not. Henry Howard, Earl of Northampton (1540–1614), King's, was chosen as Chancellor in 1612, not only because he was 'rich and a Batchelor', but because he was 'superlatively learned, a writer of Books in Queen Elizabeth's days, that especially against Judicial Astronomy is of as elegant Contexture, as any that are written in more sunny climates' (Cooper).

W. Oughtred (1574–1660) is said by Aubrey to have been an astrologer and very lucky in giving judgements in nativities: 'he would say, that he did not understand the reason why it should be so, but so it would happen. . . . The country people did believe that he could conjure, and 'tis like enough that he might be well enough contented to have them thinke so.'

On the other hand Dr. Edward Davenant (1596–1680) of Queens', nephew of the then Master, 'thank't God his father did not know the houre of his birth; for that it would have tempted him to have studyed astrologie, for which he had no esteeme at all'.

[1] Peck, *Desiderata curiosa* 1779.

At Oxford Sir Henry Savile founded Professorships of Astronomy and Geometry in 1613 and John Bainbridge (1582–1643) of Emmanuel College was chosen to fill the Savilian chair. He is said to have advertised his course by *affiches* or written papers put upon the door of the room in which he lectured. One of these notices ended in the words *lecturus de polis et axis,* under which an unknown hand had added—

Doctor Bainbridge
Came from Cambridge
  To read *de polis et axis.*
Let him go back again,
Like a dunce as he came,
  And learn a new syntaxis.[1]

John Pell (1610–85); F.R.S. 1663; entered Trinity at the age of 13, but after some correspondence with Henry Briggs at Merton in 1628, he incorporated at Oxford. He was the author of several papers on astronomy, including a

Description and Use of the Quadrant, 1628, MS. in Royal Society.

Modus supputandi Ephemerides astronomicas paradigmate ad annum 1630 accomodato.

Astronomical History of Observations of heavenly Motions and Appearances 1633/4.

Eclipticus Prognosta; or the Eclipse-Prognosticator, 1634.

In 1643 he became a professor in Amsterdam.

Jeremiah Horrox (1617?–41) entered Emmanuel as a sizar in 1632. 'The university proved of little use to him, ... yet without mathematical instruction or the stimulus of sympathy, he determined "that the tediousness of study should be overcome by industry, my poverty by patience, and that instead of a master I would use astronomical books".' By the advice of a Manchester draper, William Crabtree, he studied the works of Kepler, and with such good results that he was able to show how Kepler's Laws must be modified in order to fit the motion of the moon, owing, as he rightly suspected, to some disturbing cause emanating from the sun.

In 1635 he purchased a copy of Lansberg's *Tables,* in

[1] W. Pope, *Life of Seth Ward.*

which he wrote a list of works on astronomy. This was followed in May 1638 by the purchase of a telescope for 2*s.* 6*d.* with which he observed the partial solar eclipse of 22 May 1639 (*Opera posthuma*, pp. 387–9).

Planetary motions are caused by a tangential impulse (supposed to depend on the sun's rotation) and a central pull, an idea which he illustrated by a 'circular pendulum' described by him in a letter to Crabtree on 25 July 1638. He seems to have identified solar attraction with terrestrial gravity. He detected the 'long inequality' of Jupiter and Saturn, and placed a maximum value of 14″ on the solar horizontal parallax, estimated by Kepler at 59″ and by Hevelius at 41″. He also discovered irregularities in the motions of Jupiter and Saturn, due to their mutual attractions. And, a yet more remarkable achievement, he predicted that the positions of the planets showed that a transit of Venus would occur on 24 November 1639. Both he and Crabtree verified the transit, a great historical event, for it was the first time that human eye had witnessed this rare occurrence.

> 'I then beheld a most agreeable spectacle, the object of my sanguine wishes, a spot of unusual magnitude and of a perfectly circular shape, which had already fully entered upon the sun's disc on the left, so that the limbs of the Sun and Venus precisely coincided, forming an angle of contact. Not doubting that this was really the shadow of the planet, I immediately applied myself sedulously to observe it.'

Only four other such transits have been seen, those of 1761, 1769, 1874, and 1882. The next is due in 2004.

In 1640 he began the first continuous series of tidal observations ever made, hoping thereby to prove the earth's rotation. Sir J. Herschell called him 'the pride and boast of British Astronomy'. His papers, now in the Bodleian, were published in 1673 as *Opera Posthuma* under the editorship of J. Wallis.

The Comet of December 1664 was observed by John Ray of Trinity from the 20th to the 29th of the month. He noted that it appeared to be about 10 degrees long and when last seen to be moving at the rate of 4 degrees in 24 hours. Its position relatively to the constellations

of Hydra and Argo was shown in seven drawings posthumously published in 1707 in the *Philosophical Transactions*.

JOHN FLAMSTEED, 1646–1719, of Jesus College, was the most assiduous of observers. In 1670 Sir Jonas Moore, Surveyor of the Ordnance, made him a present of a Townley micrometer, and 'promised to furnish him with object

THE COMET OBSERVED BY RAY IN ROME.
From *The Further Correspondence of John Ray.*
Block kindly lent by the Ray Society.

glasses for telescopes at moderate rates'. In 1675 at the age of 39 he was appointed the first Astronomer Royal by Charles II at a salary of £100 a year, with full permission to provide himself with the instruments he might require, at his own expense. His observations of the orbit of Saturn and of the shape and satellites of Jupiter and Saturn, freely communicated, supplied Newton with the accurate facts which were essential for establishing his Law of Universal Gravitation. The occasion which had led in 1674 to their acquaintanceship was the amusing one that his assistance was asked by Newton, when that great man had found himself unable to adjust a microscope, having forgotten its object-glass—'not the only instance of the great Mathematician's absent-mindedness'.

In 1676 he entered into residence at Greenwich with the very modest equipment of two clocks, a sextant, and the

Townley micrometer given by Sir Jonas Moore. Seven years later he erected a Mural Quadrant by Abraham Sharp of 50 inches radius, and this was followed in 1689 by a new Mural Arc of 140° and 7 feet radius by the same maker. In 1710 Uffenbach reported on the Greenwich Quadrant, of which he published an engraving, and stated that the observatory had very few instruments.

Again in the period 1691–4 when Newton was busy with the motions of the moon, not only did Flamsteed supply him with the facts, but also with his values for the apparent displacements in altitude due to the refraction by the atmosphere—a matter of the greatest astronomical importance. In view of such signal service it was most ungenerous of Newton to end by quarrelling with his benefactor, a man who was only able to supply his needs by much personal suffering, and in spite of his having to suffer harrowing poverty to eke out the starvation wage which the Crown allowed its Astronomer Royal, by taking a cure of souls at a neighbouring parish.

Dialling

Outside the great Observatories, portable Sundials were in general use, and the construction of the hour-lines for all kinds of fixed Dials provided many an exercise for young mathematicians—indeed Horology was as important a branch of the Mathematical curriculum as was Architecture. The Hon. ROGER NORTH of Jesus, whose studies have already been quoted, p. 47, became by his own account an adept at an early age (c. 1680):

I was an early artist at *Dialling*, beginning to dabble in it about leaving school, and since attained a perfect notion of it, with which I have for the most part contented myself, not being much concerned in projection. I remember once I made a gentleman conceive the matter thus. Suppose an apple, or round part, divided into twenty-four parts, as the globe usually is by twelve circles, stained so as to pierce into the body and quite through, whereby the body would be divided into twenty-four parts by twelve planes made by such stain. Then cut the body in such a plane as your dial is to be upon, and the stains upon the surface of the section are the straight hour lines; and the body being placed according to the position of the sphere,

the intersection of the twelve planes is the axis and style of the dial. This is the notion of all dials, which one may easier conceive if he can in his thoughts reduce the whole sphere of the world into the form of a glass sphere upon its axis divided as usual, and with a sun in its place on one side and the shadow of the axis on the other, to shew the hours and what planes may be placed from the centre outwards opposite to the sun, so that lines from the centre upon the plane directed to the several horary divisions upon the sphere, the hour lines, and style are presented to the imagination. All the rest of this art is the practice, with which any man may busy himself as he sees occasion. The notion of all [dials] is but what I have described, whatever form the projection be cast into. This conceit of dialling I fell into early, and it was the first attempt above boys' play.

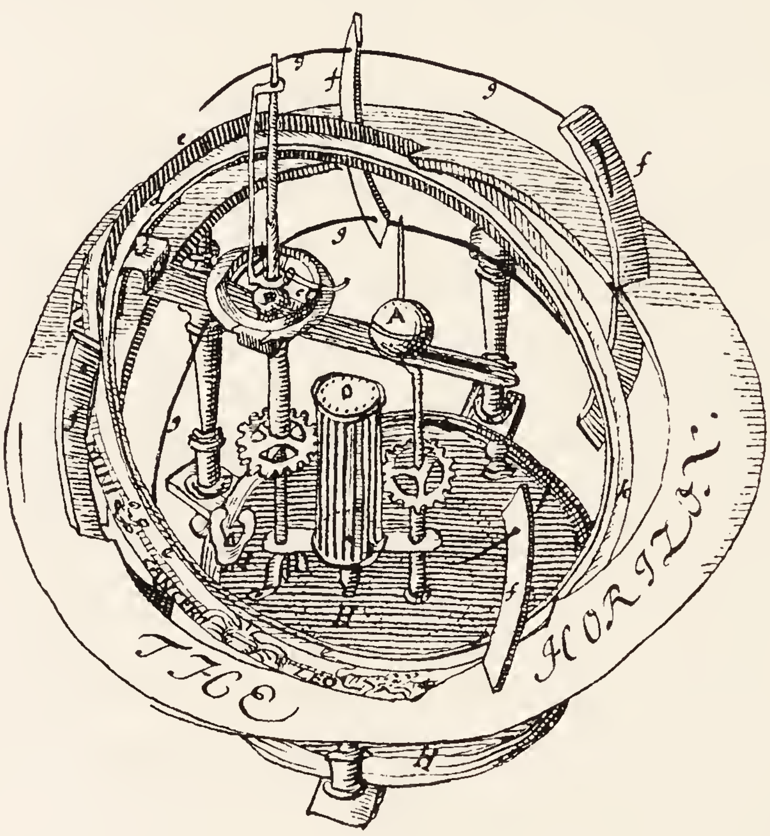
The Eighteenth Century

The numerous writings on astronomy by Cambridge authors which have been listed were the result of private enterprise, often by physicians with a leaning to astrology, or by cosmographers and travellers who were interested in the improvement of navigational methods and instruments, or yet again by compilers of almanacks. The University appears to have taken little or no interest in the science until the beginning of the eighteenth century.

That so many astronomical works should have been compiled by early physicians is readily explained by the fact that physicians have an innate curiosity and interest in biology, and that biologists, both from natural inclination and training, are interested in striking natural phenomena, including those of the heavens. In modern experience many a student, who has attained eminence in biology, has as a lad constructed his own telescope. The early interest in Astronomy shown by John Ray, 'father' of Botany, has been quoted. We may also cite the case of Stephen Hales, of Corpus Christi College, greatest of physiological botanists, who about the year 1705 is said to have been desirous of demonstrating the Newtonian system. To this end he contrived a machine, which was constructed of brass and moved by wheels, so as to represent the motions of the planets upon the same principles, and nearly in the

same manner as the machine afterwards constructed by Mr. Rowley, Master of Mathematics to King George I, which was called an *Orrery*, in honour of the fourth Earl of Orrery, Rowley's patron. This machine was supposed to be the first of its kind, but it has been stated that Dr. CUMBERLAND, Rector of All Saints at Stamford, afterwards Bishop of Peterborough, had constructed one of them before, when he was a fellow of Magdalene College, Cambridge. Unfortunately no trace of it now remains because his grandchildren were allowed to play with it until it broke into pieces.

Stukeley, whose artistic capabilities were well known, at the request of his friend, made a drawing of Hales's



planetarium. He was also requested by the Lincolnshire astronomer George Lynn to draw a map of the Moon, for it was realized, as Wren had done at an earlier day, that such was a desideratum. But Stukeley apparently did not find time for it. The first good drawings were those of Tobias Mayer, published at Göttingen 1755, and of John Russell, R.A., now in the History of Science Museum at Oxford.

The importance of Astronomy as a fit subject for academic study was certainly very widely acknowledged at

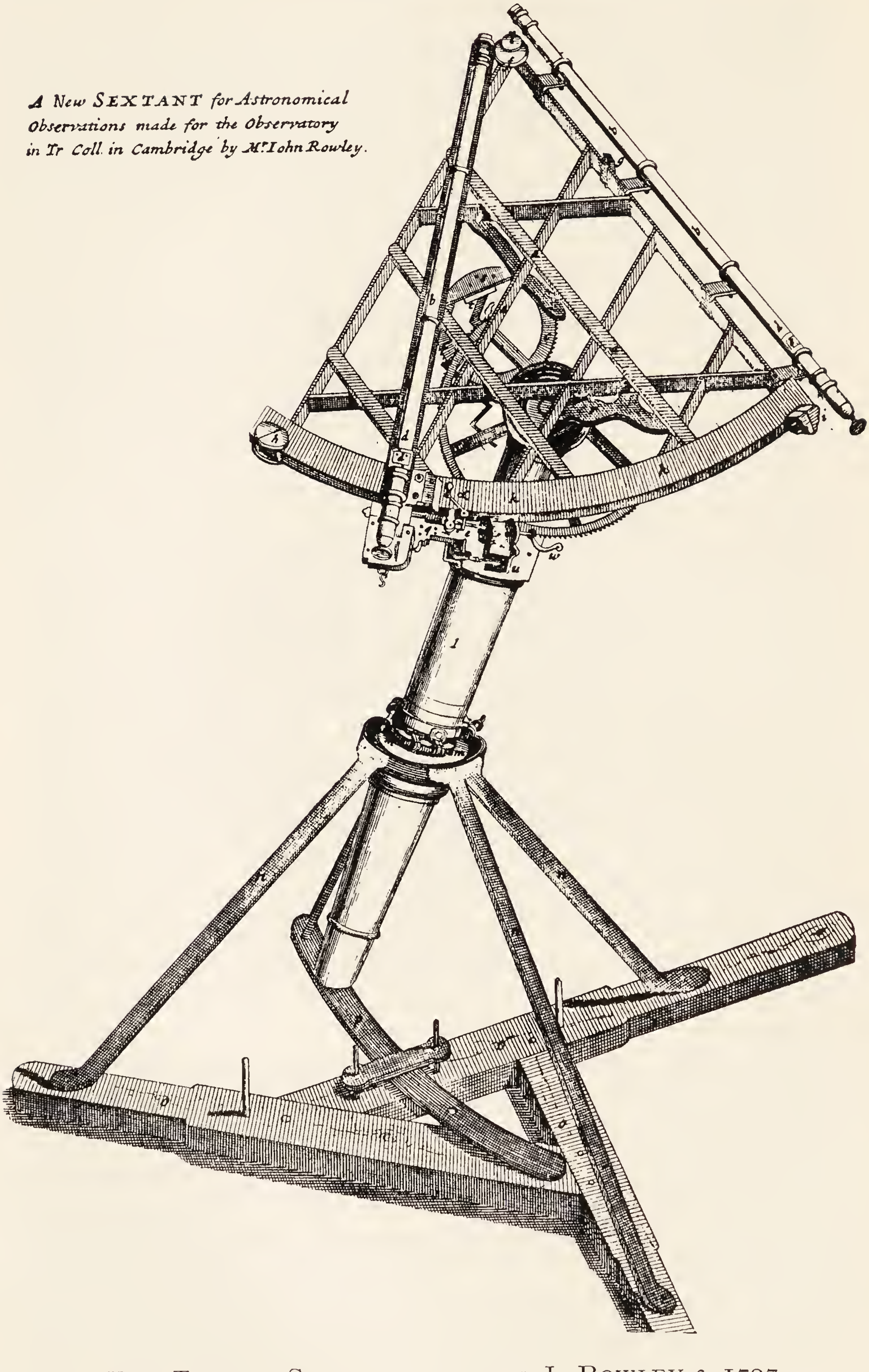
this time. It required but the touch of a benefactor. In November 1704 Thomas Plume died, and left £1,902 12*s.* 2*d.* to erect an Observatory, to maintain a Professor of Astronomy and experimental Philosophy, and to buy or build a house with or near the same. Statutes for the Professorship were passed by the Master of Caius, Sir Isaac Newton and John Flamsteed, on 14 January 1707.

The Trinity Observatory

Roger Cotes, one of the junior fellows of Trinity (1705) was elected, mainly owing to the influence of the Master, Bentley. He held the chair from 1707 to 1716. That the study of Astronomy might become naturalized and permanent in Trinity College, he opened a subscription list, by means of which an Observatory was erected on the leads over the King's or Great Gate of the College. This was furnished with the best astronomical instruments obtainable, and rooms were found for the Professor's lodgings near by, so that he and his pupils might be able to use the Observatory to the utmost advantage.[1] And Bentley was not the man to allow his protégé to forget his obligations; and so, when in a letter to Newton he recommended Cotes as a capable person to prepare the second edition of the *Principia* for the press, he wrote 'he does it at my orders, to whom he owes more than that . . .' It was doubtless due to Cotes's careful editing that Newton was able to write in his Preface: 'In the third Book the theory of the moon and the precession of the equinoxes are more fully deduced from their principles, and the theory of comets is confirmed by several examples and their orbits more accurately computed.'

Some of the equipment for this Trinity Observatory was made by John Rowley. He certainly made the sextant of 5 feet radius. This instrument was built of iron bars set both flat and edgeways, and hinged to a stout axis of lignum vitae, so as to be brought into any plane. There were two telescopes provided with cross-wires, one fixed on the right-hand edge of the sextant from which the divisions on the limb were numbered, and the other moveable with the Index. The brass limb was diagonally divided into every

[1] J. H. Monk, *Life of R. Bentley*, 1833.



THE TRINITY SEXTANT MADE BY J. ROWLEY *c.* 1707.

five minutes and by proportional parts on the index, showing every ten seconds (Harris's *Lexicon technicum*).

Some of the smaller instruments are preserved in the Library of the College. See pages 50–2.

Cotes died in 1716, when only 33 years of age.

It was at this observatory that Stephen Hales obtained his first telescopic views of the stars. It was visited by Dr. Samuel Dale of Braintree, the friend of John Ray. On 6 June 1737 he 'went to see Mr. Wilson who dwells over the Greate Gatehouse, he shewed me the observatory, in which a clock that goeth one month. It was the present of Sir Isaac Newton to the University. They correct it by the Sun and have in that room divers large tellescopes and other Mathematical Instruments, together with a double barrelled Pneumatick machine in that room and that under it, and above all in the Cupulo is a large Sextile fixt, with two Tellescopes.'

Courses of Astronomical Lectures were also being given by William Whiston (see p. 56), which were published in 1715. *Astronomical lectures read in the Publick Schools at Cambridge. Whereunto is added a collection of Astronomical Tables; being those of Mr. Flamsteed, Dr. Hally, Mons. Cassini and Mr. Street.* London, R. Senex and W. Taylor, 1715. And again as *Lectiones Astronomicae de Eclipsibus habitae*, 7 Feb. 1708/9, by Wm. Whiston (and printed 1726 in his *Praelectiones Physico-Mathematicae*). Whiston's daughter Sarah married Samuel Barker of Lyndon (1686–1759) whose son Thomas Barker corresponded with Stukeley on astronomical matters, and contributed several papers on comets and rainfall to the Philosophical Transactions between 1756 and 1771.

The suggestive name of 'The Zodiac' was given to a Club established on 10 December 1725, but the members were literary rather than astronomical. The 12 foundation members were designated by the 12 signs, but in 1728, when it needed enlargement, 6 additional 'planets' were elected.

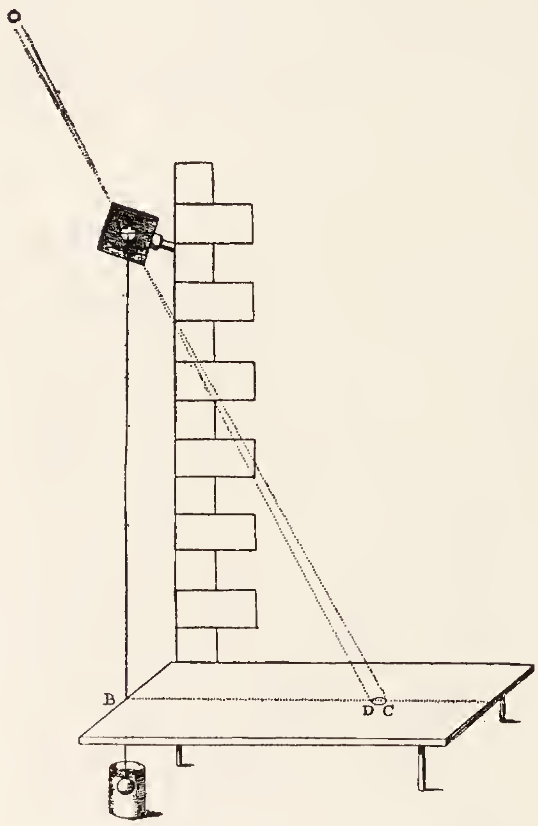
Astronomy at Pembroke College

A stray note tells us that Dr. Roger Long gave Astronomical Lectures, one of which on 26 November 1733 was

attended by John Byrom and Sheppard Frere of Trinity. The latter, who afterwards bought Roydon Hall, Norfolk, took no degree (Chetham Soc., 1855, p. 531).

Astronomy found a second benefactor in 1748 when Thomas Lowndes died on 12 May, and bequeathed his Overton Estate, lands in Smallwood, co. Chester, &c., to found a Professorship of Astronomy and Geometry with a salary of £100 a year. Roger Long, Master of Pembroke 1733–70, was the first Lowndean Professor from 1750 to 1770.

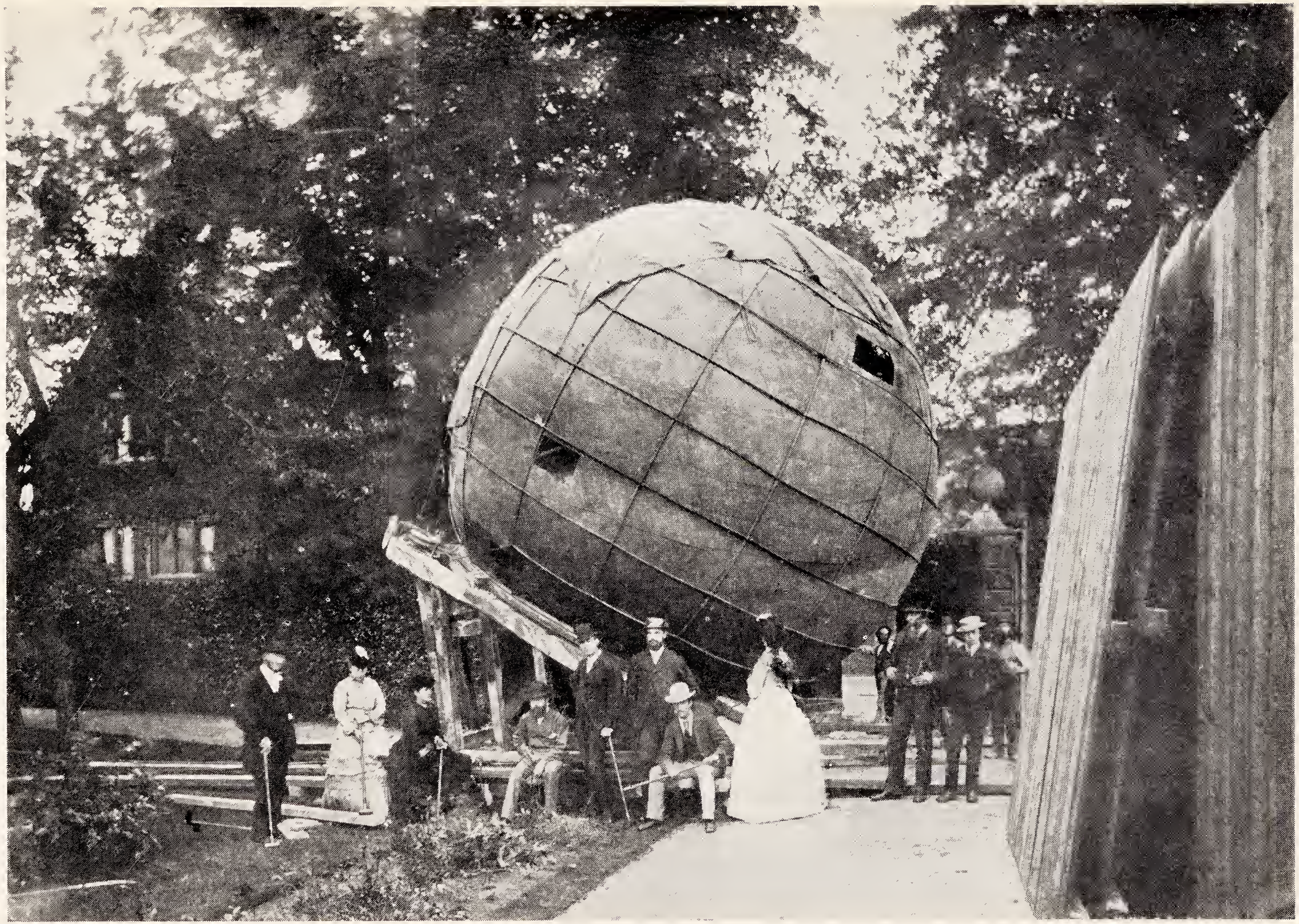
In the year 1752, assisted by Mr. Dunthorne, Long endeavoured to find *the latitude of Cambridge* by a *gnomon*:



On the outside of the south-east corner of the Chapel of Pembroke Hall, I fixed a strong round iron bar of about a foot long, fitted to the bore of a pistol barrel that it might turn easily thereon: to the pistol barrel was fastened a brass plate about 5 inches square, with an hole in the middle, wherein was put an object glass of a 17 feet telescope: by means of a string one might stand upon the ground and pull the brass into such a position that the rays of the sun would fall perpendicular upon it, when the glass would give a round image of the sun upon a plane parallel to the brass: this image was received upon a marble slab 9 feet long, roughly polished and placed in my garden upon three strong iron bars each about 4 feet long driven so far into the earth that the face of the marble was about a foot above the surface of the ground: it was exactly levelled with water kept upon it by being surrounded with a low wall of clay; then the water being removed, a meridian line was drawn thereon, upon which were marked at noon the extremities of the sun's image, now elliptical, for several days before and after the summer solstice; the noon of the solstitial day being cloudy.

PROFESSOR ROGER LONG OF PEMBROKE COLLEGE

Reprinted by courtesy of the Pembroke College Society



NO. 199. ROGER LONG'S GREAT GLOBE AT PEMBROKE HALL

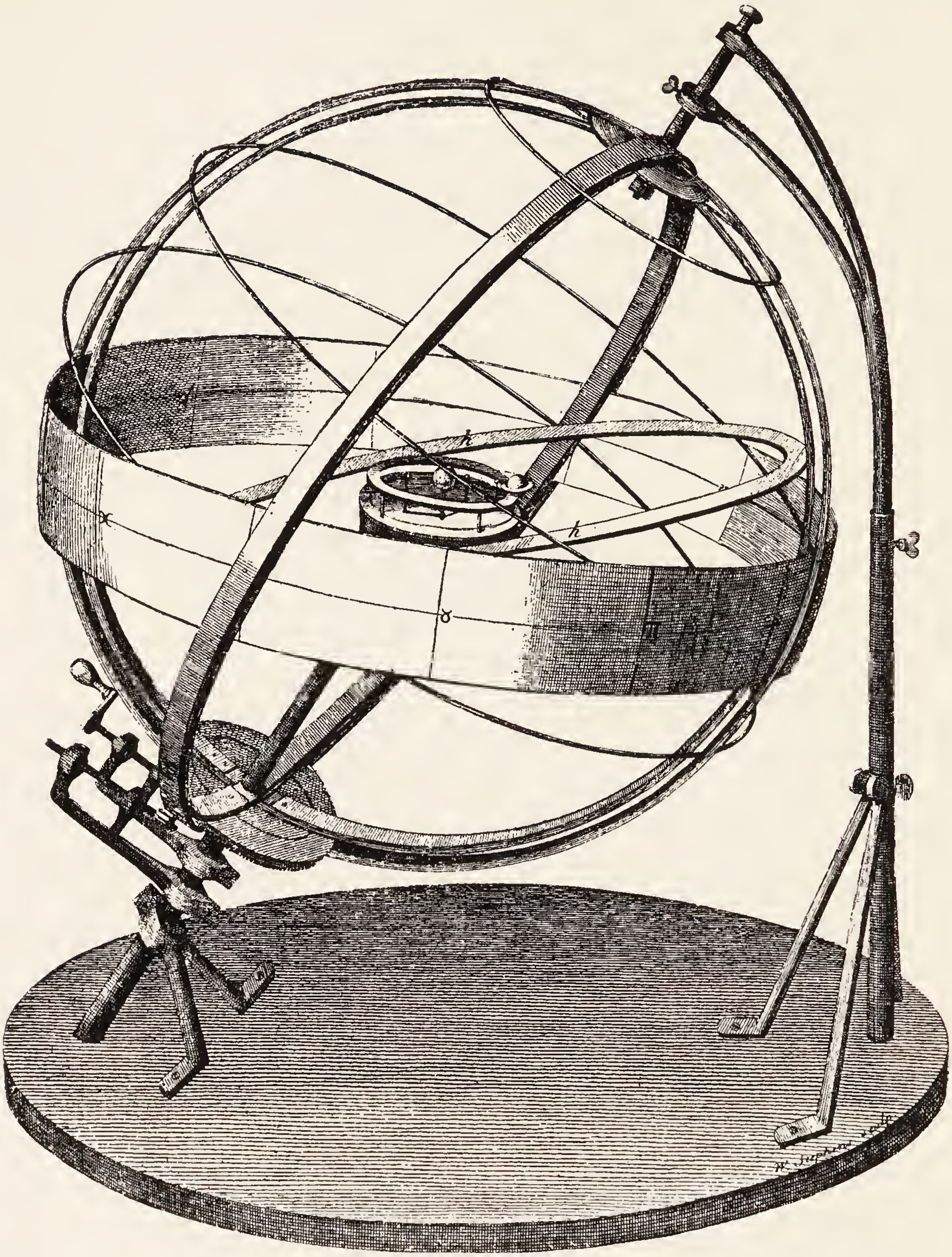
From the Pembroke College Magazine

The length of the perpendicular AB, measured from the center of the glass to the marble, was exactly 170·81 inches. To keep off superfluous light and make the image of the sun distinct, a large skreen was placed behind the brass plate with an hole to let the rays of the sun through. From a stiff wire fixed across the center of the glass upon a very small wire a leaden weight hung in water to keep it steady, and the marble was brought close to it, that the south end of the meridian line might touch the wire when it hung quietly, without pressing it out of the perpendicular: some days the wire though always suspended from the same point would not touch the marble, but there was a small space between, which I took to be owing either to the swelling of the iron rod by heat, or the shortening of the marble by cold.

The latitude of Pembroke Hall came out at 52° 12′ 55″. Long illustrated his lectures by a model which he called the *Uranium*, because it showed the heavenly bodies with their motions and appearances in a more complete manner than can be done by any other instrument that he knew of:

It consists of a *Planetarium*, or machine that exhibits the motions of the earth and all the primary planets round the sun, and the motion of the moon round the earth, all enclosed in a sphere; upon the sphere, besides the principal circles of the celestial globe, the zodiac is placed, of a breadth sufficient to contain the apparent path of the moon in all its deviations, with all the stars over which the moon can ever pass; as also the ecliptic, and the heliocentric orbits of all the primary planets. The earth in the *Planetarium* has a moveable horizon to which a large moveable brass circle marked *hh* within the sphere may be set coincident, representing the plane of the horizon continued to the starry heaven; the horizons being turned round sink below the stars on the east side, and make them appear to rise; and rise above the stars on the west side, and make them appear to set; on the other hand, the earth and the horizon being at rest, the sphere may be turned round to represent the apparent diurnal motion of the heaven. The earth and planets in the *planetarium* may be set in their true places in their orbits for any day required, by an almanack; this being done, if we stretch a thread from the earth, or

imagine a line therefrom to be drawn through the sun, moon, and each planet to the sphere, it will mark the apparent places of them for that day: the sun, moon and planets, represented



by small beads of different colours, are each of them put upon the end of a wire whereto a spring is fixed, and may thereby be put on the inside of the zodiac in their places before found; this being done the sphere turned round will shew their apparent motions, their rising, southing, and setting for the day.

This sphere may be made more compleat, if plates of tin or thin brass be hammered into segments of the same diameter, and upon the concave side of each plate one of the constellations be drawn, and fixed in its proper place: the superfluous part of the plate should be cut off, in order to leave a clear view into the inside.

But his greatest achievement was *The Great Sphere at Pembroke Hall*:

'I have, in a room lately built in Pembroke Hall, erected a sphere of 18 feet diameter, wherein above thirty persons may sit conveniently; the entrance into it is over the south pole by six steps: the frame of the sphere consists of a number of iron meridians, not compleat semicircles, the northern ends of which are screwed to a large round plate of brass with an hole in the center of it, through this hole from a beam in the ceiling comes the north pole, a round iron rod about 3 inches long, and supports the upper part of the sphere to its proper elevation for the latitude of Cambridge; the lower part of the sphere, so much of it as is invisible in England, is cut off; and the lower or southern ends of the meridians or truncated semicircles terminate on, and are screwed down to a strong circle of oak of about 13 feet diameter, which, when the sphere is put into motion, runs upon large rollers of lignum vitae, in the manner that the tops of some wind-mills are made to turn round. Upon the iron meridians is fixed a zodiac of tin painted blue, whereon the ecliptic and heliocentric orbits of the planets are drawn, and the constellations and stars traced: the great and little Bear and Draco are already painted in their places round the north pole; the rest of the constellations are proposed to follow: the whole is turned round with a small winch with as little labour as it takes to wind up a jack, though the weight of the iron, tin, and wooden circle is above 1000 pound. When it is made use of, a planetarium will be placed in the middle thereof: the whole with the floor is well supported by a frame of large timber.'

It was at this time that the History of Astronomy began to attract attention. The learned Mr. Costard of Oxford printed three letters to Martin Folkes Esq., one in 1746, another in 1748, concerning the rise and progress of

astronomy amongst the ancients; in 1767, the same author published the History of Astronomy in a quarto volume of 368 pages.

'In the introduction are propositions of trigonometry; in the body of the work he insets many problems relating to the use of the globes: he brings the history down to his own time, and gives some account of Sir *Isaac Newton's* discoveries: he treats also of the creation, and the general deluge.'

R. Heathcote, B.A. of Jesus College, Cambridge, in 1747, published another History of astronomy, a small 8^{vo} in Latin of 82 pages, 'an ingenious performance: he divides it into two parts; the first treats of the rise and progress of that science; the second, of the ancient methods of philosophising, with a short account of that of Sir *Isaac Newton*'.

The greatest name at the close of the century was that of Nevile Maskelyne (1732–1811), seventh wrangler in 1754, fellow of Trinity, who became Astronomer Royal in 1766, and held that post for forty-six years.

While on a voyage to observe the Transit of Venus in 1761 he thought out a method for determining longitudes without having recourse to an accurate chronometer. By determining the distance of selected stars from the moon, and by comparing the observed distance with positions given in tables, it is possible to find both time and longitude. But accurate and recent tables were a necessity. After his return home he persuaded the Government to issue such tables as an annual publication. They have been continued ever since as the *Nautical Almanac*, 1766 onwards. It may be doubted whether any Cambridge man has produced a more important publication.

In 1760 Antony Shepherd, St. John's 1740, fellow of Christ's 1747–83, succeeded to the Plumian professorship and occasionally lectured on Experimental Philosophy at Trinity. He prepared *Tables for correcting the apparent Distance of the Moon and a Star from the effects of Refraction and Parallax* in 1772.

It was said that in 1761 the only transit instrument in Cambridge was a 3-foot Transit, fixed by Dr. Mason in his

own room at Trinity College. Its magnification was about 18 times. He used it for getting time on the occasion of the Transit of Venus, near the end of May 1761. This event was observed from the leads of St. John's College tower with a Short Reflector of 9·6 inches focal length, and with a Dollond Refractor with a compound OG of 66⅔ inches focal length, and a single eyeglass of 1 inch focal length. Of the two observers one presumably was the Rev. W. Ludlam, then a fellow of the College.

At Trinity the use of the Observatory for astronomical purposes seems to have become intermittent, as for instance on May 6, 1763 when the Peace of Fontainebleau was celebrated by an illumination there over the King's Gate of the College, and this in the time of Dr. Robert Smith, F.R.S., Master of Trinity and Master of Mechanics to the King, and sometime 2nd Plumian Professor, 1716–60, and second Director of the Observatory, in succession to his cousin Roger Cotes.

At his death on 2 February 1768 Smith bequeathed £2,500 to increase the stipend of the Plumian Professor and for two annual prizes of £25 to two commencing B.A.s, the best proficients in mathematics and natural philosophy of their year, now known to all the world as 'Smith's Prizemen'. The Trinity Observatory was taken down in 1797. See p. 179.

St. John's College Observatory

In 1765 a second Observatory was erected on the Shrewsbury Tower between the second and third courts of St. John's College. Professor Miller found it to be 5·21 seconds east of the Cambridge Observatory, or 28·64 secs. east of Greenwich, and in latitude 52° 12′ 29″ North. The cost was defrayed by Mr. Dunthorne,[1] who gave the instruments. An appreciation of so great a benefactor appeared soon after. 'Without the benefit of an Academical education he arrived at such a perfection in many branches of learning, and particularly in Astronomy, as would do honour to the proudest Professor in any University . . . he joined to a consummate excellence in his profession a generosity without limit in the exercise of it.'

[1] 1711–75. Formerly butler of Pembroke College.

The instruments rested on a brick arch thrown across the building, whose span was 15 ft. 6 in., rise 2 ft. 1 in., and breadth 10 ft. 9 in. To take off the lateral thrust, three very large beams were laid into the N. and S. walls, across which two transverse beams were strongly secured by joggles to the three beams aforesaid. A large stone $2' \ 4'' \times 6' \ 6''$ long resting on the crown of the arch carried the piers which bore the transit. The floor was borne entirely by the side walls, so as not to touch the stones on which transit, clock, or quadrant were placed. A certain amount of settlement was noticed at first.

Sir Isaac Pennington, M.D., afterwards Professor of Chemistry (1773) and Physic (1793) was on Nov. 3, 1766 appointed to take care of the Observatory and to observe, but he was soon succeeded by a more energetic astronomer, the Rev. W. Ludlam, who published *Astronomical Observations made in St. John's College in the years 1767 and 1768. With an account of several astronomical instruments.*[1] 1769.

The original equipment, figured on pages 195 to 201, given by Mr. Dunthorne, included:

Transit, by Sisson 1763, with aperture 1·4″, and focal length 3′ 5″. It had an entire graduated circle and the index was a diameter with a vernier at each end. The S. meridian mark was a part of the tracery of the battlements of King's College: the N. meridian marks were two dots on the wall of a house in Bridge Street. It was furnished with 3 transit wires until 1811, spaced equally in 1798; 5 wires from 1811 to 1832.

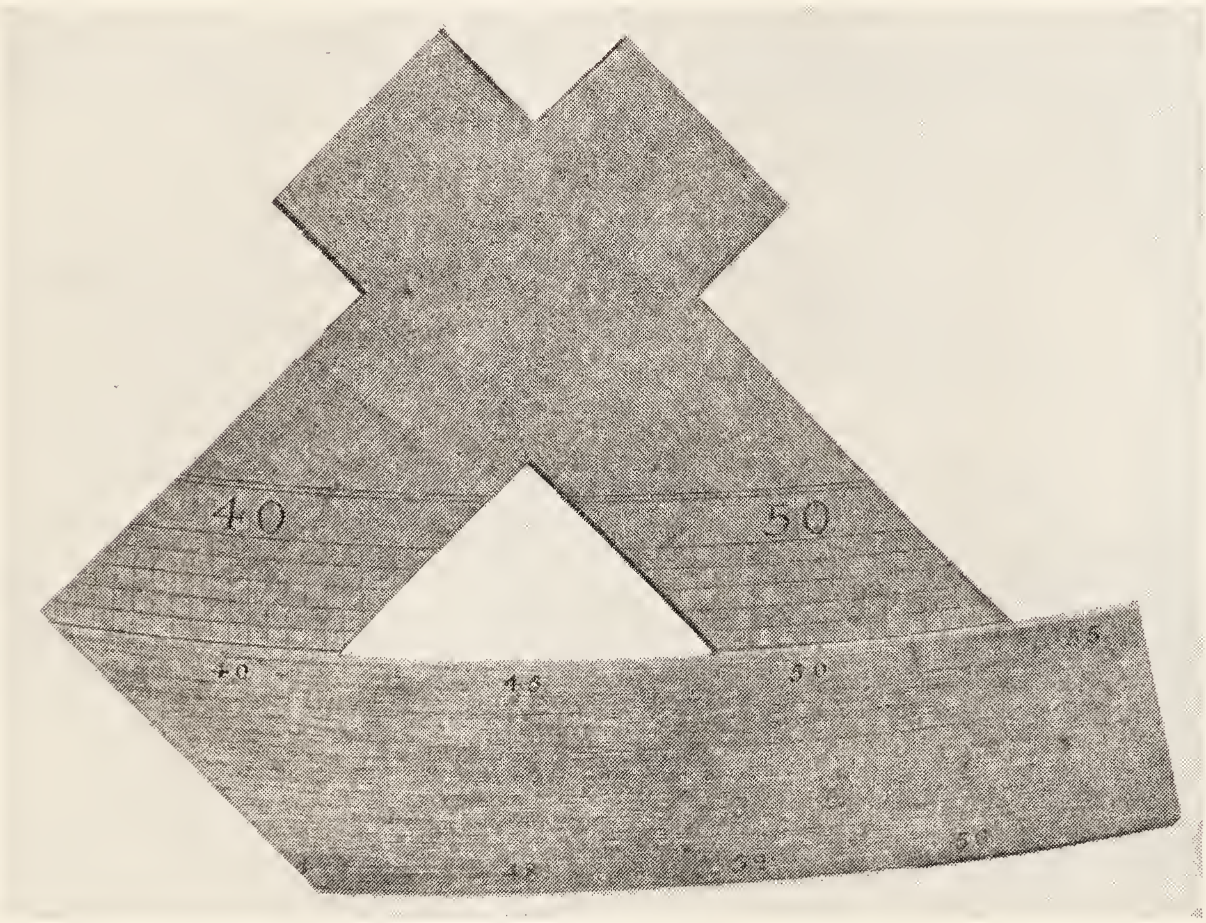
Astronomical Clock, by Shelton, with a grid-iron pendulum. It had previously, from Jan. 1765, stood in a private room in the College. It was rated by Ludlam.

18-inch Quadrant originally made by Bird for Dr. Bliss. This was mounted on a vertical axis, by which it could be turned to any azimuth. It could also be brought into any plane, but having no perpendicular bars is much too weak to be trusted in any but a vertical position. Dr. Bliss prevailed on Bird (much against his inclination and judgement) to rivet a new limb upon the old one (which had

[1] Cf. *The Eagle,* 1871, vol. vii, pp. 334–7; A. F. Torry, *Founders and Benefactors of St. John's College,* 1888. Ludlam was a fellow of St. John's 1744–69, and Sadlerian Lecturer 1746–69.

diagonal divisions), to divide it afresh by his own method, to make two new telescopes to it, and to mount the whole on a pedestal. The division into 96 parts in every quadrant is preferable to that into 90°. (Ludlam p. 47.)

The minutes were subdivided into every 4″ by a micrometer-screw with an index. The quadrant was set upright by a plumb-level seen against two very fine points, in the manner of that at Greenwich.



No. 222. Part of Limb of Bird's 18-inch Quadrant, showing the New Scale superimposed on the Original Limb

The equipment also included the following:

4-inch *Gregorian Telescope.*
2½-inch *Gregorian Telescope.*
3¾-inch *Equatorial Refractor* by Dollond.
Altazimuth by Cary.

From 1791 to 1832 Thomas Catton (1760–1838), F.R.S., fellow of St. John's 1784, observed eclipses, and occultations in the College Observatory. Cf. *Mem. R.A.S.* xxii, republished in 1853. His initials 'T.C.' are on two boxes containing a 10-inch Reflecting Circle marked 'Troughton

London 218', and its stand. He observed with a $3\frac{1}{2}$-foot transit, with a 46-inch Refractor by Dollond, aperture $3\frac{3}{4}$ inches, and (after 1811 and until 1832) a 42-inch Dollond achromatic Refractor. Catton had been placed fourth among the Wranglers, although, according to the general opinion, he should have been Senior Wrangler, an opinion which was confirmed by his subsequently being adjudged the first Smith's prize.

The *Rev. Th. Catton's Astronomical Observations, reduced* . . . by G. B. Airy, were published in 1853.

Dr. James Wood, F.R.S., the 31st Master and a great benefactor to the College, gave a Telescope probably by Dollond. He is remembered by his text-books on Mechanics and Optics.

It is pleasant to note the friendly neighbourly collaboration between fellows of the adjacent colleges of Trinity and St. John's when timing the eclipses of the sun on Feb. 11, 1804 (Rev. T. Jones of Trinity) and on Sept. 7, 1820 (Mr. Lunn observing in Prof. Cumming's garden in Jesus Lane, some 500 yards east of St. John's).

The St. John's Observatory was closed down in 1859 when the new University Observatory on the Madingley Road was opened. For a number of years the instruments have been stored in the College Library.

In 1796 Samuel Vince (1749–1821) succeeded Antony Shepherd as Plumian Professor, and held the post till his death in 1821. Apart from his mathematical text-books, he was the author of a *Treatise of Practical Astronomy*, in which the construction and use of instruments was explained, and a monumental work entitled *A Complete System of Astronomy* 1797–1808.

The Nineteenth Century

That the King's Gateway of Trinity was more suited for illuminations and fireworks than for the serious observation of the stars must have been patent to all for many years. It corresponded in a way to the early Oxford observatory of the Savilian Professors on the Tower of the Schools in the Bodleian Quadrangle, which had been superseded by the Radcliffe Observatory at Oxford about 1775.

But it was not until 1822 that any advance was made at Cambridge, mainly through the efforts of George Peacock, to provide something better.

On 28 March an Act, Stat. 3 Geo. IV, c. 17, was passed authorizing the sale of ground for the erection of an Astronomical Observatory and other purposes. A plot about 7 acres in extent, near the Madingley road, was purchased of St. John's College; and on this the Observatory was built. The total cost was about £19,000, of which £5,644 15*s*. 0*d*. was raised by subscription. The architect was John C. Mead.

In the case of at least two famous men of science, astronomy was an inherited science. Francis Wollaston of Chiselhurst passed on his enthusiasm to his son W. HUGH WOLLASTON, who wrote an essay *On the Finite Extent of the Atmosphere* in 1822 as the result of his observation of a transit of Venus in May 1821, and later wrote a paper *On a method of comparing the Light of the Sun with that of the Fixed Stars.* (*Phil. Trans.* 1829.)

Sir JOHN FREDERICK WILLIAM HERSCHEL (1792–1871), St. John's College, Senior Wrangler 1813, too, showed himself a loyal son by completing his father's work on double stars, and publishing a memoir on their orbits. The same spirit doubtless inspired him to go out to the Cape in 1833 to make a survey of the southern hemisphere. His well-known *Outlines of Astronomy* is still a most useful introduction to the science.

A third great name was that of GEORGE BIDDELL AIRY (1801–92), who came up to Trinity College at the age of 18 and graduated as Senior Wrangler and Smith's Prizeman in 1823. In 1826 he became Lucasian Professor, and in 1828 succeeded to the Plumian chair, and was placed in charge of the University Observatory. Airy had already established his reputation by papers on: *The figure of the Earth*, and *On the use of silvered glass for the mirrors of astronomical telescopes*; while in the science of Optics he had written *On the principles and construction of the achromatic eye-pieces of telescopes, and on the achromatism of microscopes*, a research which was so highly esteemed, that the Copley Medal of the Royal Society was awarded to him in 1831.

He also wrote *On a peculiar defect in the eye and a mode*

of correcting it. The defect, now known as astigmatism, was his own. One of his eyes could not focus properly a point of light drawn out into a straight line, but he found that a cylindrical lens was an adequate corrective. Airy was not aware that he had been forestalled in his observation by Thomas Young, but Young had only had to deal with slight cases and had considered that an ordinary lens slightly inclined was sufficient to correct the defect.

That honoured guests were occasionally given dinner at the Observatory is clear from the amusing invitation to Dr. and Mary Somerville, written by Dr. Adam Sedgwick in April, 1834.

It is also noted that on Aug. 25th 1834 Mr. Spring Rice [Lord Monteagle] wrote to Airy to enquire whether he would accept the office of Astronomer Royal if it were vacant. He replied (from Keswick) on Aug. 30th, expressing his general willingness, but stipulating for his freedom of vote, etc. On Oct. 30th following he wrote to ask for leave to give a course of lectures at Cambridge in case that his successor at Cambridge should find difficulty in doing it in his first year. All this arrangement was for a time upset by the change of Ministry which shortly followed. At Keswick, between August 22 and August 29, Airy records also that he wrote his paper *On the Calculation of Perturbations* for the Nautical Almanac. (*Nature.*)

At Greenwich Sir George Airy's chief work was to speed up the reduction and publication of all observations. He found arrears of observations of planets extending over 80 years; also 8,000 lunar observations requiring reduction.

For determination of Longitude at that time navigators were accustomed to measure the distance between the moon and certain stars, and to rely on the Greenwich tables of the position of the moon, consequently the preparation of such tables was one of the chief responsibilities of the Astronomer Royal. The necessary observations were made with a transit telescope which could only be used when the moon was passing the meridian. To facilitate the work, Airy in 1843 persuaded the Board of Visitors to order an instrument by which the position of the moon could be measured in any position.

The automatic system of transmitting time signals from

Greenwich was also due to Airy. A further discovery due to him was a hitherto unrecognized inequality in the motions of Venus and the Earth due to their mutual attraction.

In 1836 JAMES CHALLIS, 1803–1882, succeeded Airy both as director of the Observatory and as Plumian professor of Astronomy. He had been Senior Wrangler in 1825. His first paper was on the extension of Bode's law to the case of the satellites of the planets, read to the Cambridge Philosophical Society in 1828.

'Prof. Airy gave an account of recent results obtained at the Observatory, at a meeting of the Cambridge Philosophical Society held on May 4, 1835, namely, 1st, That the discrepancy of the observations of the obliquity of the Ecliptic at the summer and winter solstices formerly noticed, had disappeared on using the refraction corresponding to a new barometer which stands 1–10th of an inch higher than one formerly used. 2nd, That the mass of Jupiter, as determined by observations of the 4th Satellite in 1834, is almost exactly the same as that obtained in 1832 and 1833, namely 1–1048th of the Sun's mass. 3rdly, That the time of rotation of Jupiter, as determined by a spot, is 9h, 55m, 21s: the spot from which the determination was obtained made 225 revolutions in 93 days.'

The Vicar of Maidenhead, the Rev. GEORGE C. GORHAM, 1787–1857, the second Smith's prizeman in 1808, reviewed the recorded appearances of Halley's Comet from 1456 to 1835. (*The Times*, Jan. 26, 1836.)

In 1835 the Cambridge Observatory received a welcome addition, a **Telescope** of nearly **12 inches aperture** and 20 feet focal length made by Cauchoix of Paris, and presented by the Duke of Northumberland, High Steward.

The Observatory clocks are by *Graham*, *Molyneux & Cope*, and *Hardy*.

The heavy cost of the erection and fittings of the Observatory, the New Anatomical Schools and the Mineralogical Museum together proved over-burdensome to the University, so in 1843 a Syndicate was appointed to inquire into the diminished funds of the University.

An appreciative visitor to the Observatory at this period was Frederick Augustus, King of Saxony. He inspected it

under the guidance of Dr. C. G. Carus, who then took him on to Trinity where they were shown a portion of Newton's hair and some instruments that had belonged to him, including the earliest and imperfect form of his 'Refractor' (20 June 1844).

Meanwhile one of the greatest episodes in the history of Cambridge was in preparation.

Early in the 19th century the path of the outermost known member of our planetary system was being carefully re-examined by M. Bouvard, of Paris, with the result that he detected certain deviations from a simple orbit, which he considered might be due to another planet at a greater distance still. This bold suggestion in 1834 so attracted the Rev. J. T. Hussey that he wrote to the Astronomer Royal offering to make a search for the planet, if some idea of its position could be given him.

An undergraduate of St. John's College also became interested, and on 3rd July 1841 wrote the following note: 'Formed a design, in the beginning of this week, of investigating, as soon as possible after taking my degree, the irregularities in the motion of Uranus, which are yet unaccounted for; in order to find whether they may be attributed to the action of an undiscovered planet beyond it; and, if possible, thence to determine the elements of its orbit, etc., approximately, which would probably lead to its discovery.'

The writer, JOHN COUCH ADAMS (1819–92), graduated as senior wrangler in 1843, and forthwith set to work on the problem, with such success that by September 1845 he was able to communicate a first solution to the head of the Cambridge Observatory, JAMES CHALLIS, and also the position at which the new planet might be expected to be seen, to Airy at Greenwich about November 1. Had Airy searched, he would probably have found the planet, but he appears to have done nothing, except to address a further inquiry to Adams.

Meanwhile, Leverrier, a young Parisian, made an independent calculation whence a position for the unknown planet was derived which agreed so closely with Adams's position, that Airy suggested to Challis that he should make a search on July 9, 1846. Three weeks later Challis

began sweeping the sky for the suspected planet, and actually observed it on August 4th without recognizing it!

On September 18 Leverrier wrote to Galle at the Berlin Observatory, and within a week the search was successful, and Cambridge Observatory lost the credit of having been the first to find the planet Neptune. The disappointment to Adams must have been severe, and with Schuster and Shipley we cannot absolve either Airy or Challis from blame.

Adams became Lowndean professor and director of the Observatory in 1858.

He published investigations on the secular acceleration of the moon's mean motion and on the orbit of the swarm of meteors known as the Leonids (1867), whose period is about thirty-three years.

On 7 April, 1848 the Senate approved regulations for an Adams Prize to commemorate the fact that John Couch Adams of St. John's had been the first to determine from perturbations the unknown place of a disturbing Planet exterior to Uranus.

The Rev. RICHARD SHEEPSHANKS (1794–1856) was tenth wrangler in 1816 and became a fellow of Trinity in the next year. For a number of years he served as secretary of the Royal Astronomical Society, and later as one of the board of visitors of the Royal Observatory at Greenwich. He determined the longitudes of Antwerp, Brussels, Liverpool, and Valencia. His valuable private collection of astronomical instruments was deposited with the R.A.S., who in 1930 made it over to the Lewis Evans Collection, and it is now an important exhibit in the new Museum of the History of Science in Oxford.

Mr. Sheepshanks was a protagonist in a controversy of incredible acrimony with Charles Babbage and Sir James South, in which John Taylor also intervened. This verbiose campaign began in 1851 and only ceased when Sir J. South fired his final shot after the death of Sheepshanks in 1856.[1]

The problem of the rings of Saturn was tackled by CLERK MAXWELL who came to the conclusion 'that the only

[1] Manuel Johnson's copies of the controversial pamphlets came to the Radcliffe Observatory whence they were transferred to the Oxford History of Science Museum in 'Tracts vol. 6 A.'

system of rings which can exist is one composed of an indefinite number of unconnected particles revolving round the planet with different velocities according to their respective distances. These particles may be arranged in a series of narrow rings, or they may move through each other irregularly. In the first case the destruction of the system will be very slow, in the second case it will be more rapid, but there may be a tendency towards an arrangement in narrow rings which may retard the process'. His model is preserved in the Cavendish Laboratory.

Charles Pritchard (1808–93), St. John's, 4th wrangler 1830, had been thirty years head of Clapham Grammar School, and a President of the Royal Astronomical Society, when at the age of 63 he was appointed to the Savilian Chair of Astronomy at Oxford, where he organized the new University Observatory and advocated the use of Photography for accurate measurements and in photometric determination.

The work of Sir George Howard Darwin (1845–1912) was concerned with the mathematical theory of the tides. In its simplest case the problem assumes the earth to be a rigid solid sphere covered with water of a uniform depth. But when account is taken of all the factors—of the combined attractions of sun and moon, of an unequally distributed ocean of varying depth, and of a yielding core to the earth, it follows that there must be a frictional effect which must slow down the rotation of the earth, and slowly drive the moon farther away. Conversely in the past the earth must have been spinning more rapidly, and the moon must have been nearer, and, if we go back far enough, would actually have been part of the earth. Sir George Darwin's researches have most materially helped to establish the scientific basis for such a study. A medal struck in his honour is in the Trinity College Library.

In 1870 the Cambridge **Mural Circle** by *Dollond* was replaced by a **Meridian Circle** by *Troughton & Simms* with an 8-inch object-glass by *Cooke*, purchased from the Sheepshanks fund.

Plumian Professorship of Astronomy, 1704.

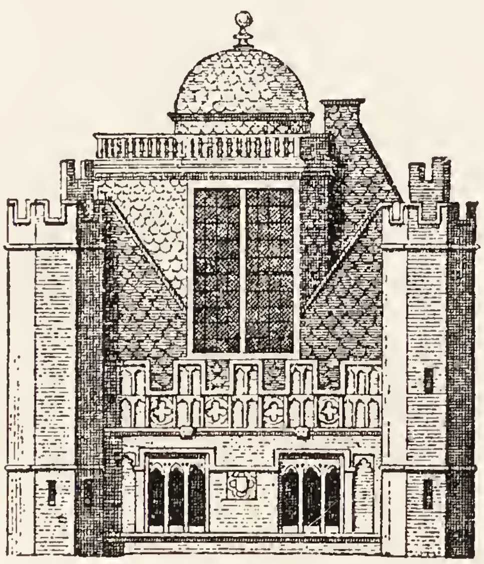
1.	Roger Cotes	1706
2.	Robert Smith	1716
3.	Antony Shepherd	1760
4.	Samuel Vince	1796
5.	Robert Woodhouse	1822
6.	Sir George Biddell Airy	1828
7.	James Challis	1836
8.	George H. Darwin	1883
9.	Arthur Stanley Eddington	1913

Lowndean Professorship of Astronomy and Geometry, 1749.

1.	Roger Long	1750
2.	John Smith	1771
3.	William Lax	1795
4.	George Peacock	1837
5.	J. Couch Adams	1859
6.	Sir Robert S. Ball	1892
7.	Henry Frederick Baker	1914
8.	William Douglas Vallance Hodge	1936

Professorship of Astrophysics, 1909.

1.	Hugh Frank Newall (*Emeritus*)	1909
2.	Frederick John Marrion Stratton	1928



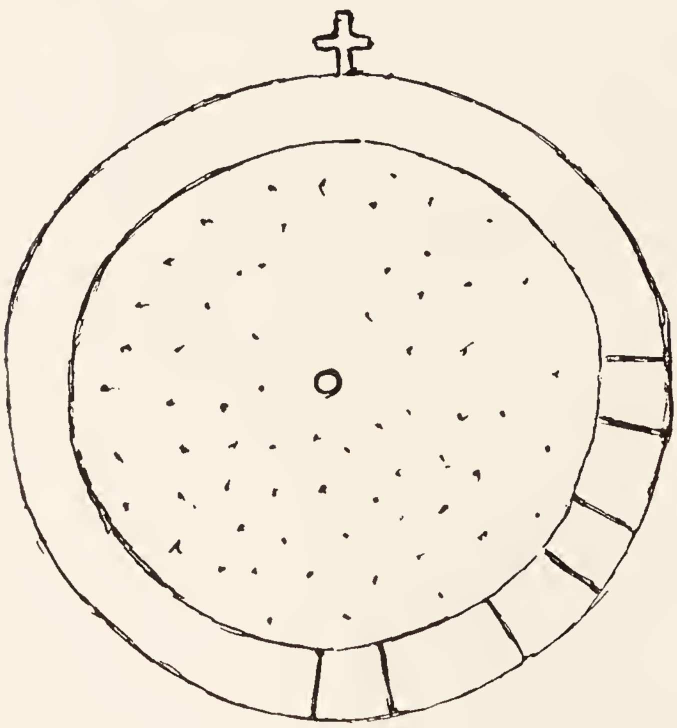
The Observatory on the Great Gate of Trinity College, 1740.
From Willis Clark, *Architectural History of Cambridge*.

ASTRONOMICAL INSTRUMENTS

SUN-DIALS

Saxon dials are few and far between. The rebuilding of churches and the refacing of walls and buttresses have swept most of them away, and the change of the method of time-reckoning from the four tides into which the Saxon day was divided to the twelve hours helped to render the earlier dials obsolete. Dr. F. J. Allen has, however, sent me a photograph of a sun-dial which Dom Ethelbert Horne has considered to be Saxon. It is cut on a stone (Northants oolite), about 12 inches across, inserted in a Norman wall of Hauxton Church. I should prefer to term it an early *Scratch Dial.*

144. Mural Dial. **Late Anglo-Saxon.**



Formerly on Old Chapel of St. John's Hospital. Now in Archaeological Museum.

145. Circular Scratch Dial. **c. 12th cent.**
Little St. Mary's Church, formerly St. Peter's outside the gate.

146. Scratch Dial—style hole only. **c. 12th cent.**
St. Peter's on the Hill.

Other Scratch Dials have been recognized on churches at Kingston, Madingley and Littleport.

147. Circular Mural Dial. **14th cent.**
Godmanchester, Hunts.

About 18 inches in diameter on a buttress about 6 ft. from the ground. Finely designed after the pattern of a rose-window with eight radial lights. Radii indicate tides and half-tides. The Style is probably not original.

HAUXTON DIAL.

153. GODMANCHESTER DIAL.

148. Polyhedral Dial. Diam. c. 16 inches. **c. 1670.**
Arch. Mus.

Restored with gnomons in 1913 by Professor Sir W. Ridgeway and his wife Lucy Ridgeway, and presented c. 1926. A similar example is in the Palace of Schwerin (Gatty, *Book of Sundials*, 1900, p. 176). Such dials were common in Scotland, c. 1620–1720, but this one came from Ireland.

149. Cube of Dials. c. 1675.

Formerly on Gate Tower, Caius College.

Engraved by Loggan, *Cantabrigia*, 1675. A group of 60 dials designed by Theodor Haveus of Cleves, stood on a column in the Court in the 16th century, and there were others.

150. Horizontal Sun-dial. 16 inches in diameter. 1795.

Replacing one of 1704 in the Great Court of Trinity College.

By [J. & E.] TROUGHTON, *LONDON*

Cumberland's Meridian Line.

Brown's Hospital, Stamford.

A meridian line was drawn on the wall of Brown's hospital by the 'diligent' Richard Cumberland (Magd. Coll.), Bishop of Peterborough, when vicar of St. Martin's, Stamford.

151. Mural Dial. 1733.

Replacing one of 1642 in Queens' College. See p. 206.

Doubtfully ascribed to Sir Isaac Newton. It was 'beautifully ornamented with variety of useful Furniture'. A still older one dated from 1538.

Loggan shows other dials in the Colleges of Christ's (for which Skinner was paid £1. 15*s*. in 1671), Jesus, Magdalene, and St. John's.

PORTABLE DIALS

For the 13th-century text of the **Chilindre** or **Pillar Dial** see p. 130.

152–5. 3 Ivory and 4 Boxwood Cylinder Dials.

C. H.-White Collection.

156. Paper Cylinder Dial.

C. H.-White Collection.

By *Henry Robert Paris.*

158

166 159 166

COMPASS DIALS

157. Oughtred's Double Horizontal Dial. c. 1640.

Engraved on the back of his 'Circles of Proportion' (p. 35). It includes

A Calendar Circle of days of months.

A Circle of Star positions marked: 'Cor ♌, Spi ♍, Lanx bor, Cap oph, Vultur, Os peg, Ext ala, Luc γ, Ocu γ, Seg ori, Can min, Cor ♌.'

COMPASS DIALS

158. 16th-cent. Sun-dial. Diam. $1\frac{3}{4}$ inches; found in 1895 on site of the Cavendish Laboratory. **16th cent.**

159-62. French Octagonal Compass Dials with adjustable Bird gnomons. 18th cent.

Fitzwilliam Museum.

(*a*) Brass. Signed, *C. Langlois. A Paris au Niveau Pour 52 Degrez.* c. 1730–40.

(*b*) Silver. Signed, *Langlois. Aux Galleries du Louvre.* c. 1740.

(*c*) Brass. Signed, *P le Maire. A Paris.* ?c. 1750.

163. Augsburg Dial.

Archaeological Museum.

Signed *Nicolaus Rugendas.*

164. French Dials with Bird-gnomons.

Prof. A. Hutchinson.

By *Macquart à Paris.*

165. Ivory folding Dial, marked I 3 K.

Prof. A. Hutchinson.

166. Oval Universal Sun-dial. 'c. 1700–10.'

Fitzwilliam Museum.

NON-COMPASS DIALS

167–8. Analemmatic Dials. ?c. 1760.

Fitzwilliam Museum.

(*a*) 6 in.×4 in. By 'Thomas Heath'.

(*b*) Unsigned in C. H.-White collection.

ASTRONOMICAL RING DIALS

169–70. Astronomical Ring Dials. **1652.**

C. H.-White collection, Fitzwilliam Museum.

(*a*) By *Anthony Thompson in Hosier Lane near South of A° 1652.*

(*b*) *Edm. Culpeper fecit.* Undated.

171. $4\frac{1}{2}$-inch Astronomical Ring Dial. **1660.**

Arch. Mus.

Hen: Sutton fecit 1660, for Will^{m}. Rook.

172. $6\frac{3}{8}$-inch Astronomical Ring Dial. **c. 1670.**

Trinity College.

Silver. In case, lid missing. Star list engraved on back.

'This Dial belonged to S^{r} Isaac Newton. It came into my possession when the observatory upon the great Gateway of Trinity College, was pulled down [1797], in which the astronomical Instruments were deposited, used by Sir Isaac Newton when residing in that College.' C. Hague. (Trinity Hall, Prof. of Music, 1799.)

It came into the possession of Frederick Luard Wollaston of Trinity Hall, and was given to Trinity by Mrs. Frederick Stewart Sandemann in 1916.

173. 10-inch Astronomical Ring Dial. **1703.**

Trinity College.

'Made by John England, Charing Cross, London, Colleg. Trinit. Cantab. 1703'. A Quadrant on back.

174. 12-inch Universal Ring Dial on Stand. **c. 1730.**

Prof. A. Hutchinson.

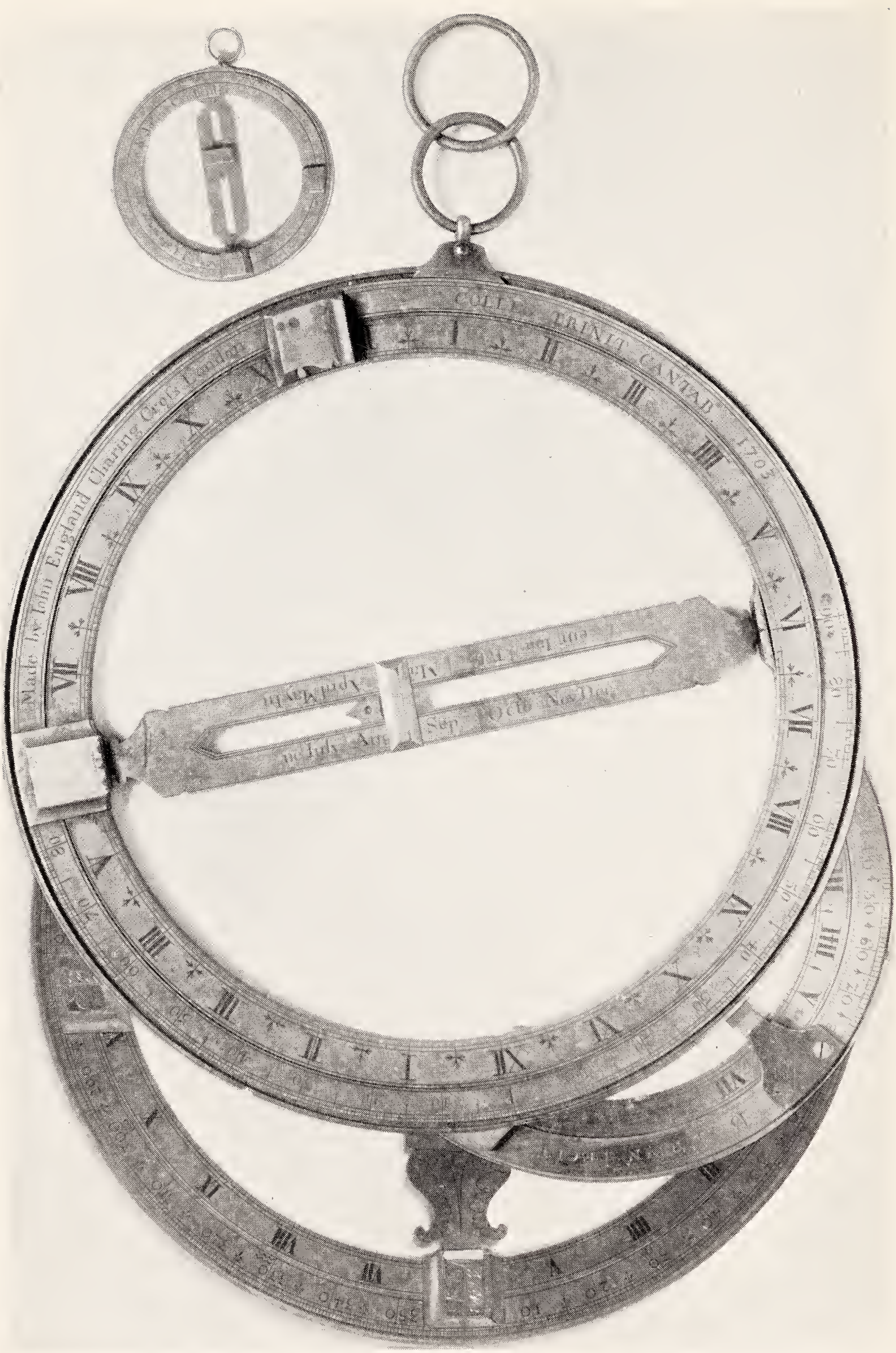
'Made by Heath and Wing London.'

T. Heath was a math. instrument maker at the Hercules next the Fountain Tavern in the Strand.

'The Universal Dial whereby the Hour of the Day, Sun's Azimuth, Altitude, and Variation of the Compass is readily observ'd to the greatest Exactness', figured in Hammond, *Practical Surveying*, 1731.

UNIVERSAL RING DIAL AND STAND BY T. HEATH

Lewis Evans Collection



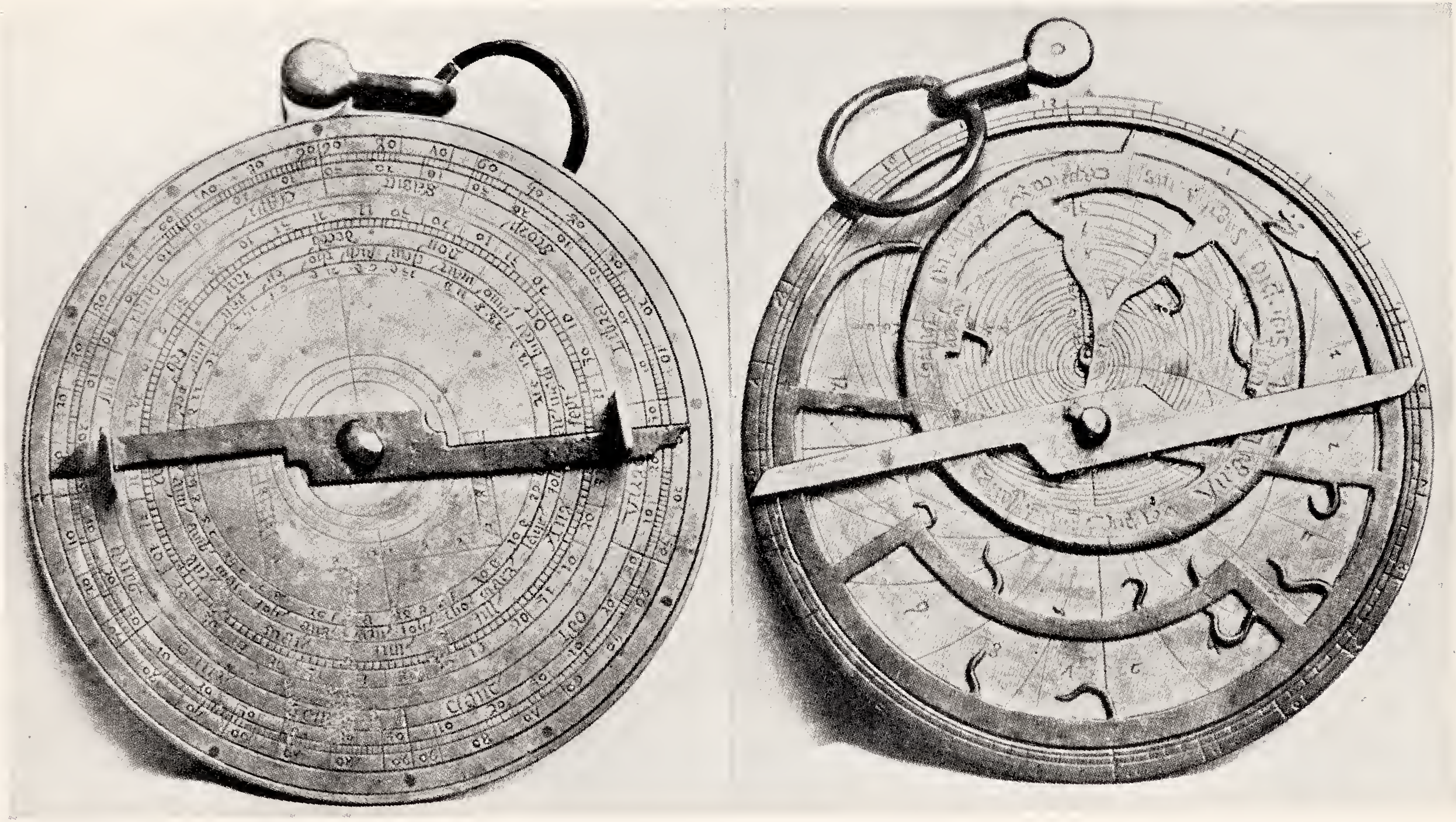
ASTRONOMICAL RING DIALS

No. 181. *St. John's College.*

No. 178. *By John England, 1703*

No. 180. *By B. Martin*

No. 177. *Anonymous*



NO. 132. CAIUS COLLEGE ASTROLABE (B)

175–7. Three Astronomical Ring Dials. c. 1730?
Fitzwilliam Museum.

One by 'B. Martin Fecit.' Other two unnamed.

178. Astronomical Ring Dial. 1737.
St. John's College.

Inscr. 'J. Colemore 1737 Soph. at St. John's Cambridge'. Pres. 1927. A John Colemore adm. St. J. 1733, B.A. 1737–8; curate of Edlesmere, Bucks.

ASTROLABES

179. Dr. Caius's Astrolabe (B). 14th cent.
Caius College.

Diameter $3\frac{1}{2}$ inches. Believed to have belonged to Dr. Caius. Figured in *Astrolabes of the World*, pl. 132.

Face.

The margin is divided into intervals of 3 degrees. The rete is provided with pointers for 19 stars, of which the names of 12 only are legible. There are no separate Latitude Plates, but the inner surface of the venter is engraved as a plate for '*Lat*[*itude*] *nor*. 52'.

On the *Back* are engraved quadrantal and calendar circles and a circle of the following Saints' Days:

March	12.	Gregorius.
,,	25.	Annunciatio Dominica.
April	4.	Ambrosius.
,,	25.	Marcus.
May	6.	Johannes Ante Portam Latinam.
,,	26.	Augustinus Anglorum.
June	11.	Barnabas.
,,	34.	Nativitas S. Johannis Bapt.
July	7.	Translatio S. Thomae.
,,	20.	Margaretha.
Aug.	10.	Laurentius.
Aug.	29.	Decollatio S. Johannis Bapt.
Sept.	8.	Nativitas B. V. Mariae.
,,	21.	Matthaeus.
Oct.	18.	Lucus.
,,	28.	Simon et Judas.
Nov.	11.	Martinus Turonensis.
,,	23.	Clemens.
Dec.	6.	Nicolaus.
,,	21.	Thomas.
Jan.	6.	Epiphania Domini.
,,	25.	Conversio S. Pauli.
Feb.	2.	Purificatio B. V. M.
,,	22.	Cathedra S. Petri in Antiochia.

In the middle is a Square of Shadows of the ordinary form.

180. Caius College Astrolabe (A). **15th cent.**

Caius College.

By Hooft.

Diameter $5\frac{1}{4}$ inches. In leather case stamped with Tudor Portcullis and word 'Gages'. Rete for 23 stars. One Latitude plate for 49° and 50° (Nuremberg).

Two paper plates are printed from engraved plates for lat. of Paris 48° 50′ and of Jerusalem 32°. Six other brass plates are incomplete.

The positions of the stars were determined by Dr. Knobel who compared them with the positions given by Al Tizini in 1553, see *Astrolabes of the World*, p. 345.

181. King's College Astrolabe. **c. 1570–80.**

King's College.

Unsigned.

Diameter 11 inches, perhaps by a Netherland craftsman.

Figured and described in *Astrolabes of the World*, p. 393.

With plates engraved 'pro elevatione poli' 39° (Lisbon) and 41° (Naples); 45° (Venice and Lyons) and 52° 30′ (Cambridge); 48° (Munich) and 51° (Antwerp). Rete for 31 stars.

Back engraved with a stereographic projection of sphere.

182. Kufic Arabic Astrolabe. **A.H. 933. A.D. 1526.**

Professor Newall.

183. Persian Astrolabe of Muhammad Mahdi al-Khadim. **1659.**

Arch. Mus.

Figured and described in *Astrolabes of the World*, p. 136.

Diameter $4\frac{1}{2}$ inches. Inscribed on the bracket with the name of the maker, Muhammad Bakir Isfahani; and round the ankabut 'It is the mirror of Alexander, and the mirror representing the whole Universe', whence may be read a chronogram giving the date A.H. 1770 or A.D. 1659.

A small compass-box of silver is fitted into the back of the kursi.

KING'S COLLEGE AS

.ABE, XVI CENT.

The history of this instrument is intriguing. In 1855 it belonged to Mr. Williams, the Assistant Secretary to the Royal Astronomical Society. In 1892 on the death of Professor Couch Adams his widow presented it to the Cambridge Museum, but how it came into the Professor's possession is not recorded.

The tablets figured show star maps in polar projections of the Northern and Southern hemispheres, and a double projection.

184–6. Three Oriental Astrolabes.

C. Holden-White Collection.

QUADRANTS

187–9. Brass Quadrants.

C. H.-White Collection, Fitzwilliam Museum.

(*a*) *A. W. fecit* 1639.
(*b*) *Elias Allen fecit.*
(*c*) Unsigned, but provided with a screw for clamping to a stand.

190. 9-inch Quadrant. **18th cent.**

Archaeological Museum.

Engraved on a square plate; a compass dial on back.

191. 5-inch Quadrant. **c. 1660.**

Trinity College.

'Trin. Coll. Cant. Ex dono Tho. Scattergood.' On back a scale of the equation of time.

192. $5\frac{3}{4}$-inch Gunter's Quadrant. **17th cent.**

Jesus College.

See p. 50.

193. 7-inch ditto.

Prof. A. Hutchinson.

194. $4\frac{1}{2}$-inch Surveyor's Quadrant.

Trinity College.

With two sets of slit-sights and a 2-inch compass. The rim is graduated in degrees from 0° to 90° in opposite directions, each degree being subdivided into $\frac{1}{3}$rds.

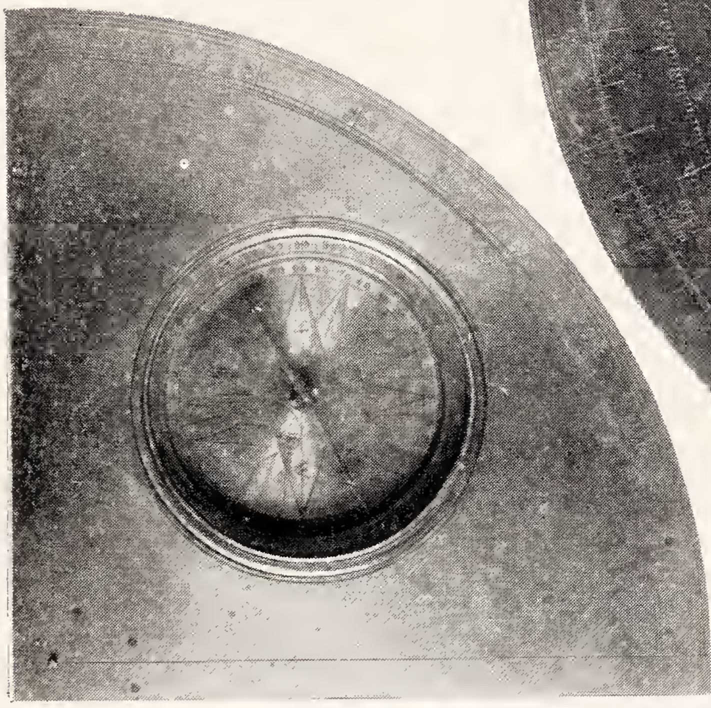
NOCTURNAL

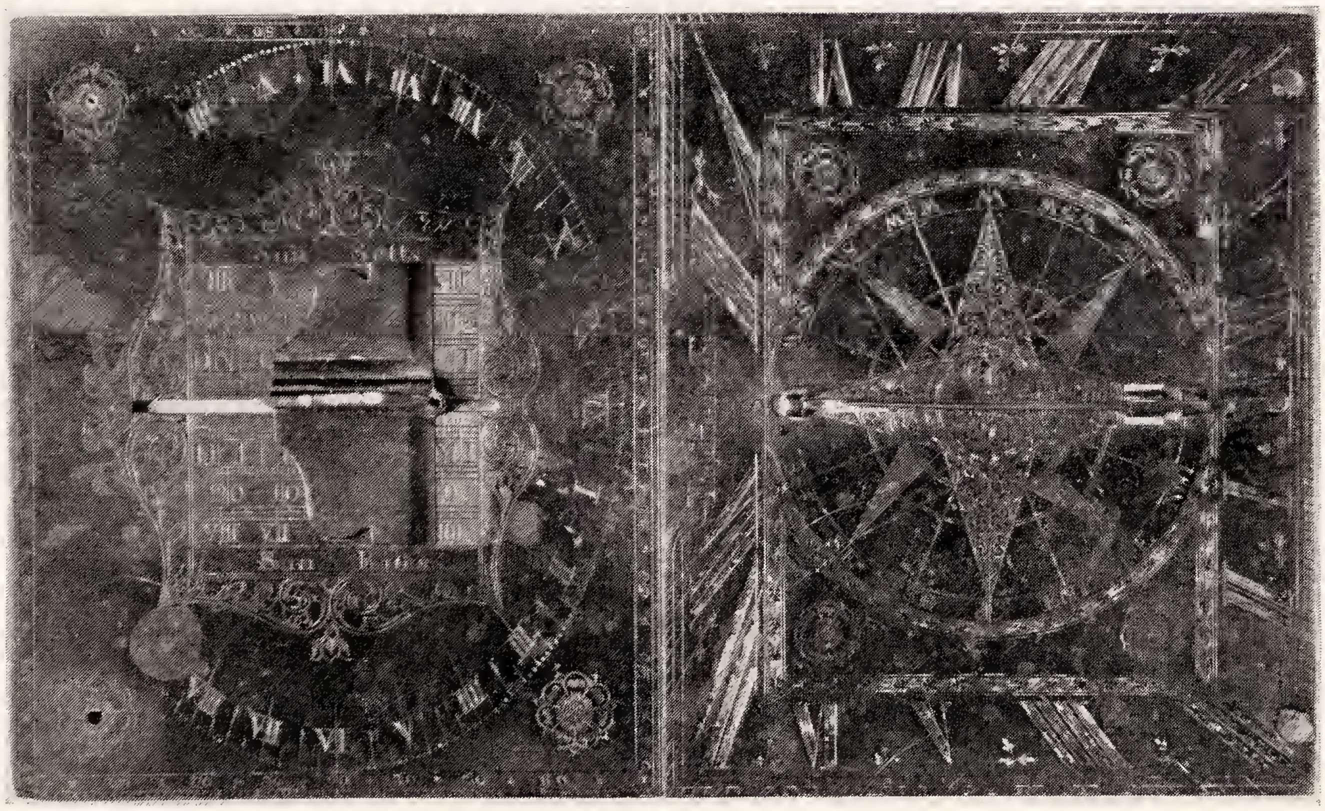
195. 3-inch Nocturnal. **Early 18th cent.**

In Dr. Addenbrooke's cabinet of Materia Medica in St. Catharine's College.

It may have belonged to James Symonds, son of James Symonds of Norwich, who matriculated at St. John's in 1667 and became vicar of Dagenham, 1704–19.

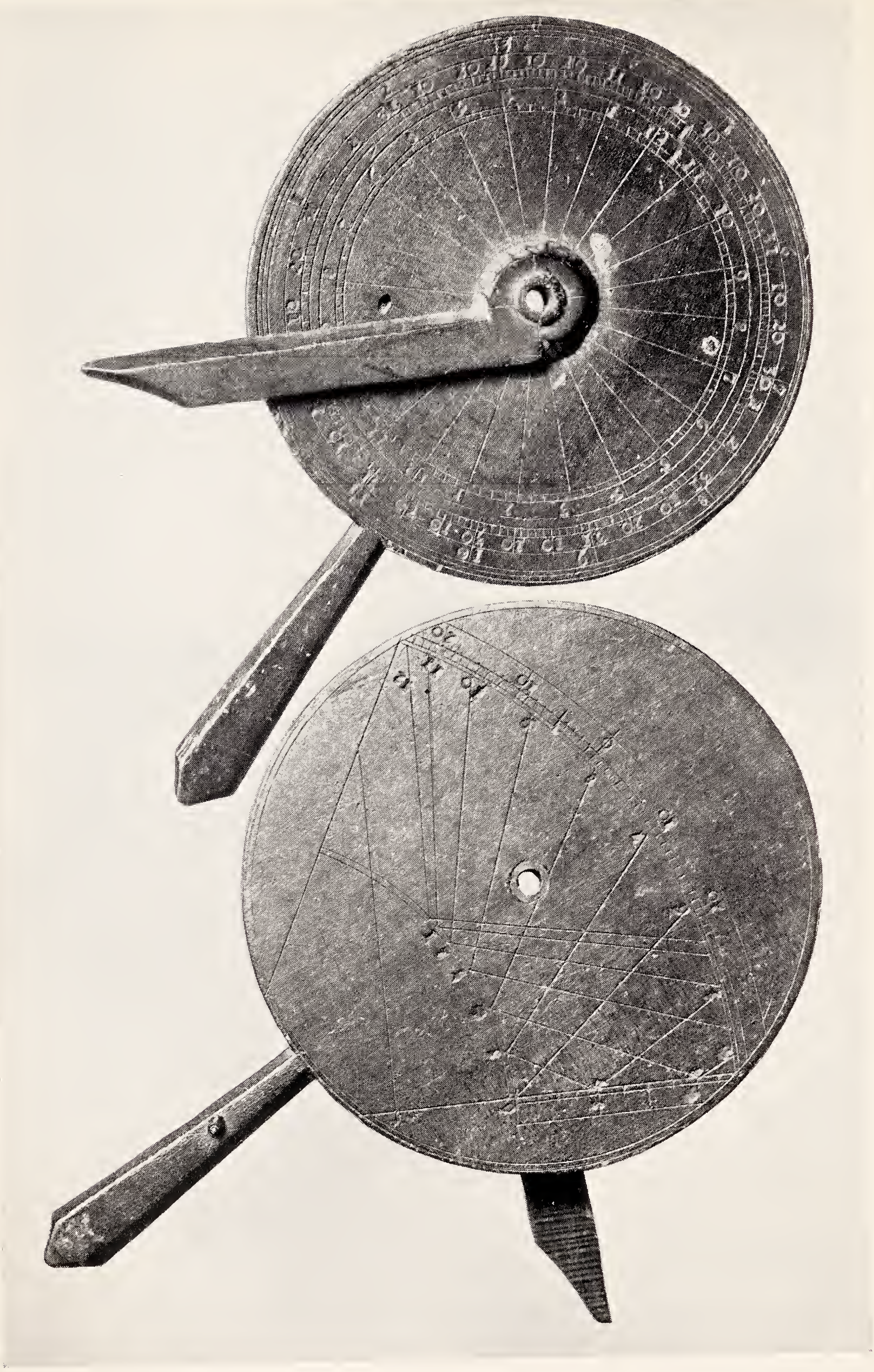
No. 194 No. 191





TRINITY COLLEGE QUADRANTS

No. 172. HEATH'S ANALEMMATIC DIAL



NO. 195. NOCTURNAL
St. Catharine's College

CELESTIAL GLOBES AND PLANETARY MODELS

196. The 'English' Globe. **1679.**

Trinity and Pembroke Colleges.

'By the Rt. Hon. the Earl of Castlemaine, made and sold by J. Moxon.'

Supported by a pillar on four legs over a celestial planisphere showing the constellations. It is marked with the coat of arms of Castlemaine. Diameter 11 inches.

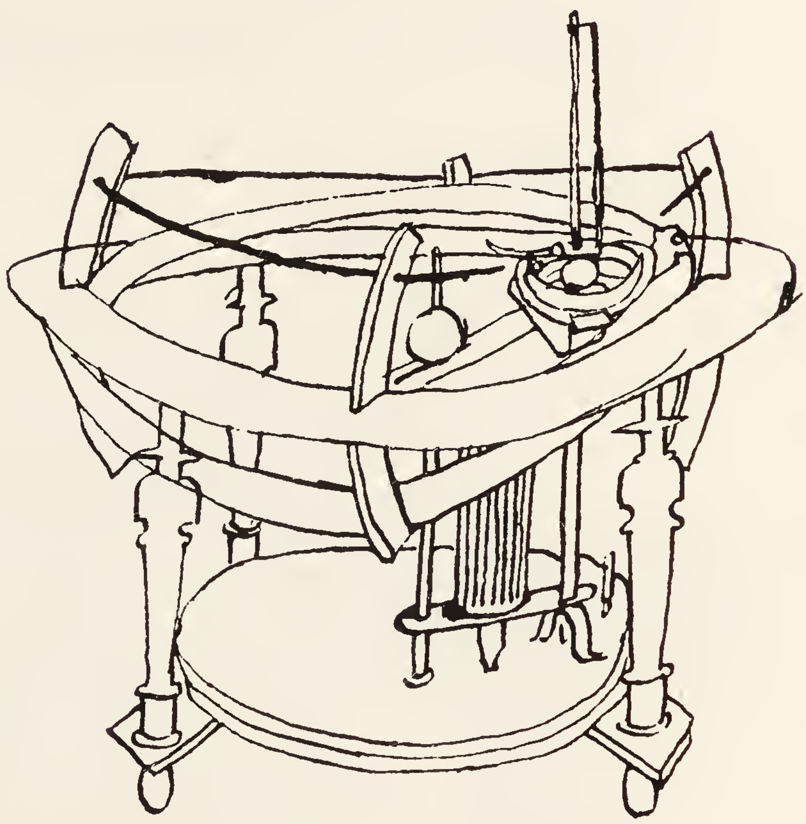
Described in a book entitled, *'The English Globe invented and described by the Right Honorable the Earl of Castlemaine. And now publisht by Joseph Moxon, Member of the Royal Society.'*
Fundasti Terram super Stabilitate sua—Psal. 104. 5.
London 1679.

197. Wooden Celestial Globe with Zodiac. **?18th cent.**

Queens' College.

198. Stephen Hales's Planetarium. **c. 1705.**

According to a sketch by Stukeley this machine was invented and executed by Stephen Hales at Corpus Christi College, *c.* 1705. Stukeley's sketch is preserved in Gough Maps 230, fol. 12.



199. Long's 18-foot Sphere. **c. 1750.**

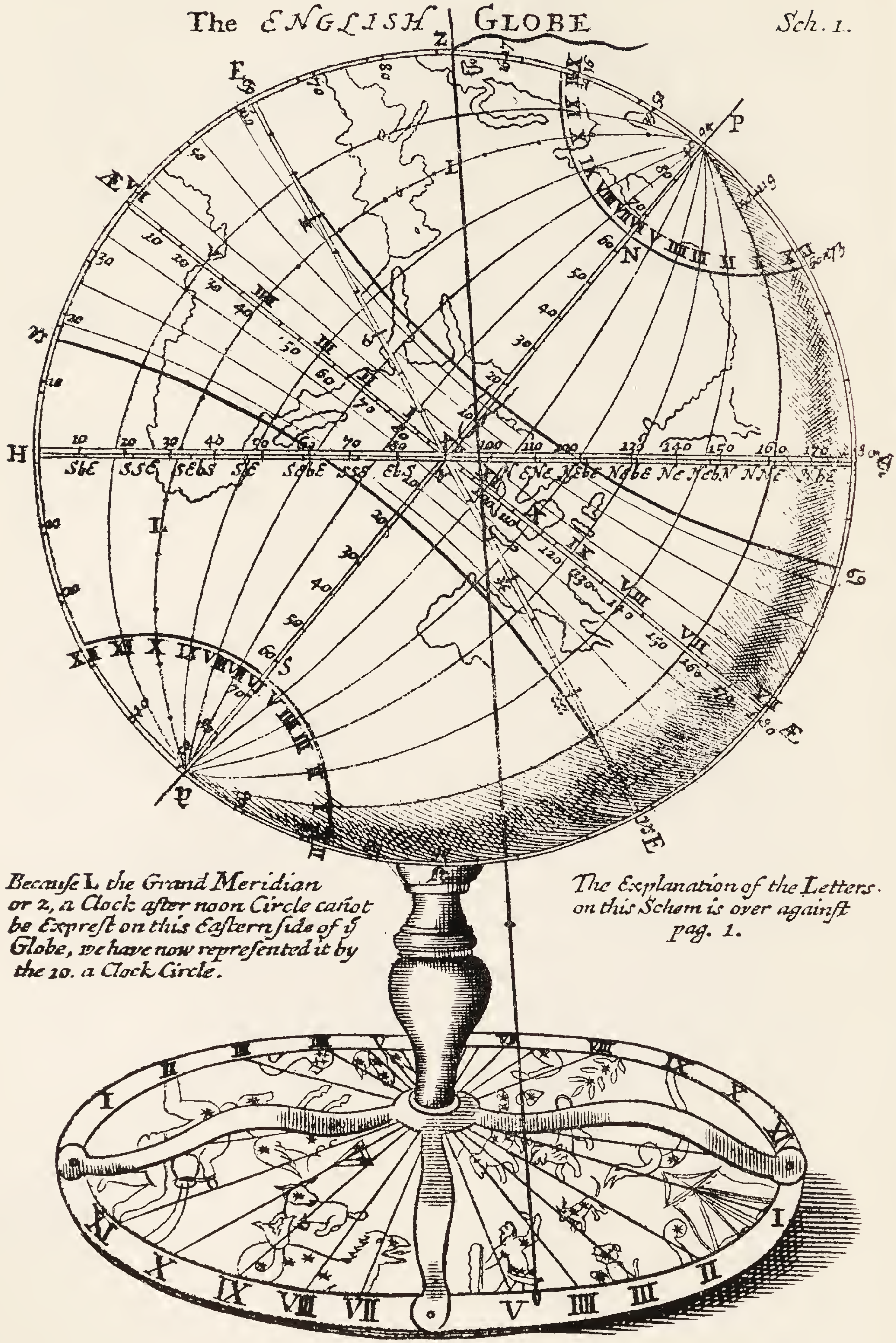
Pembroke Hall.

This large rotating sphere was erected in Pembroke Hall by Dr. Roger Long to show celestial movements. It was furnished inside with seats for 30 people. It stood until 1871.

200. Lunae solarium. **1747.**

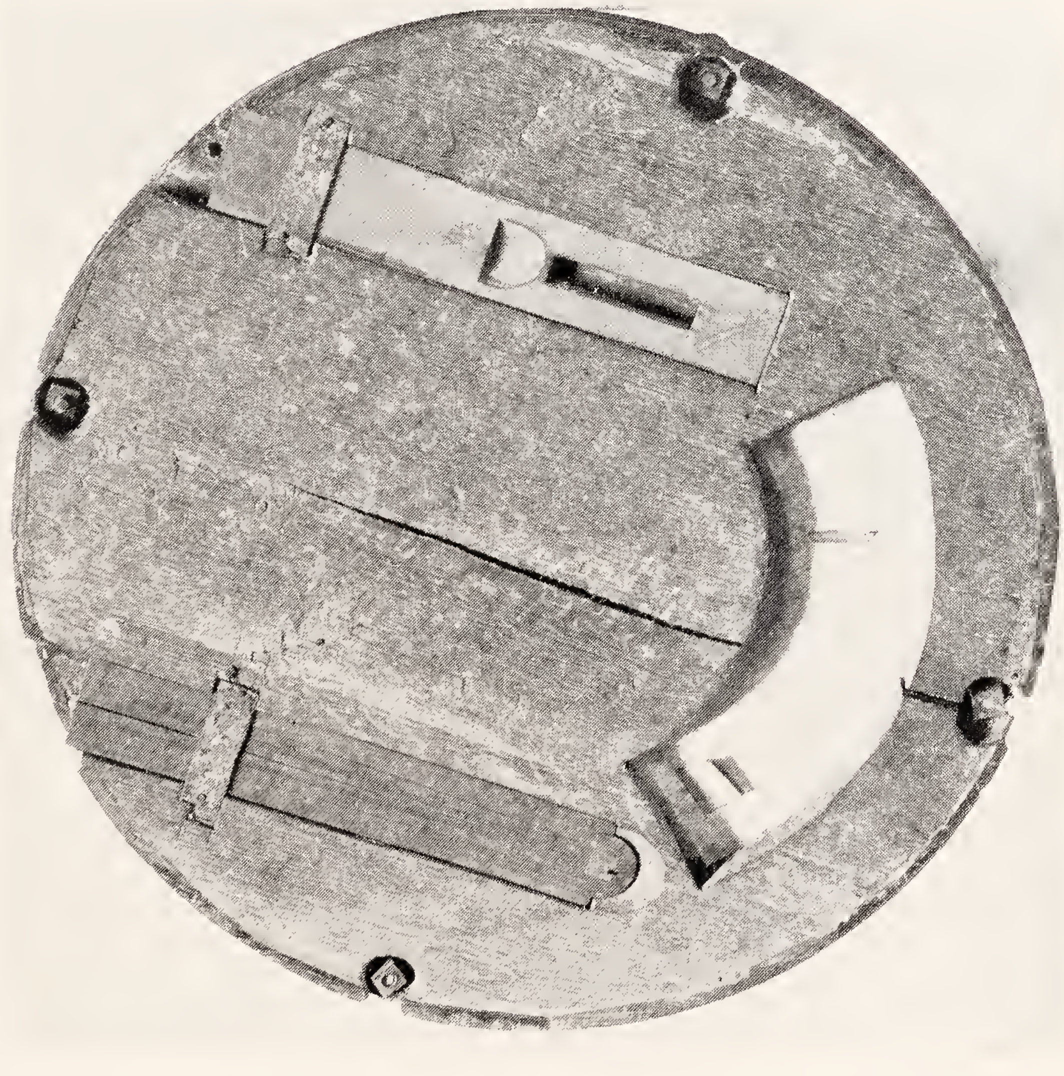
By Dr. W. Stukeley of C.C.C. Now lost.

'The same month of March [1747] I finish'd my pretty machine called Lunaesolarium, which the Duke of Montagu was highly delighted with.' Stukeley *Diary.*


The ENGLISH GLOBE
Sch. 1.
Because L the Grand Meridian or 2, a Clock after noon Circle cañot be Exprest on this Eastern side of y Globe, we have now represented it by the 10. a Clock Circle.
The Explanation of the Letters on this Schem is over against pag. 1.

No. 196.

CELESTIAL PLANISPHERE UNDER THE ENGLISH GLOBE



SECTOR UNDER THE BASE OF THE ENGLISH GLOBE

CASTLEMAINE'S ENGLISH GLOBES

Pembroke College *Trinity College*

NO. 201. THE GRAND ORRERY OF ST. JOHN'S COLLEGE, BY G. ADAMS

201. Grand Orrery. **c. 1750.**

Formerly in St. John's College, now Sedgwick Museum.

Inscription in a clock dial of the 24 hours:—'Made by Geo. Adams at Tycho Brahe's Head in Fleet St. London.'

Presented by Rev. Peter Mason, A.M., late President of St. John's College, to the Sedgwick Museum, 1904.

It is mounted on a 12-sided box-base 3 ft. 6 in. across, on a table 4 ft. square. The figures of the Zodiacal signs are painted on the 12 sides of the box-base. Jupiter and Saturn and other planets are mounted on circular discs painted blue. The Earth is smaller than in earlier examples. The principal circles are inscribed 'Artick Circle, Tropick of Cancer, $\frac{1}{2}$ Equatorial Circle 180°–360° Hours VI to XII to VI.' 1st of Aries corresponds to March 9. The domed glass roof is provided with a ring for suspension by tackle.

202. New and Improved (20-inch) Celestial Globe. **1799.**

Sedgwick Museum.

'Made and sold by J. and W. Cary No. 181 Strand', on tripod stand with 9-inch compass box at base.

203. Universal Orrery and Globe. **1848.**

Arch. Mus.

Registered in May 1848 by John Davies Hailes of Linton, Cambs.

204. New Celestial Globe. **1861.**

School of Geography.

Diameter, 28 inches.

By M. W. Newton. Manufactured by *Newton & Son, Chancery Lane.*

205. 9-inch Globe of Mars. **Before 1873.**

Trinity College.

Presented in 1873 by Capt. Hans Busk

CALENDARS

206. Clog Almanack. **17th cent.**

St. John's College.

Length 10 inches.

207. Runic Primstaff in shape of a Sword.

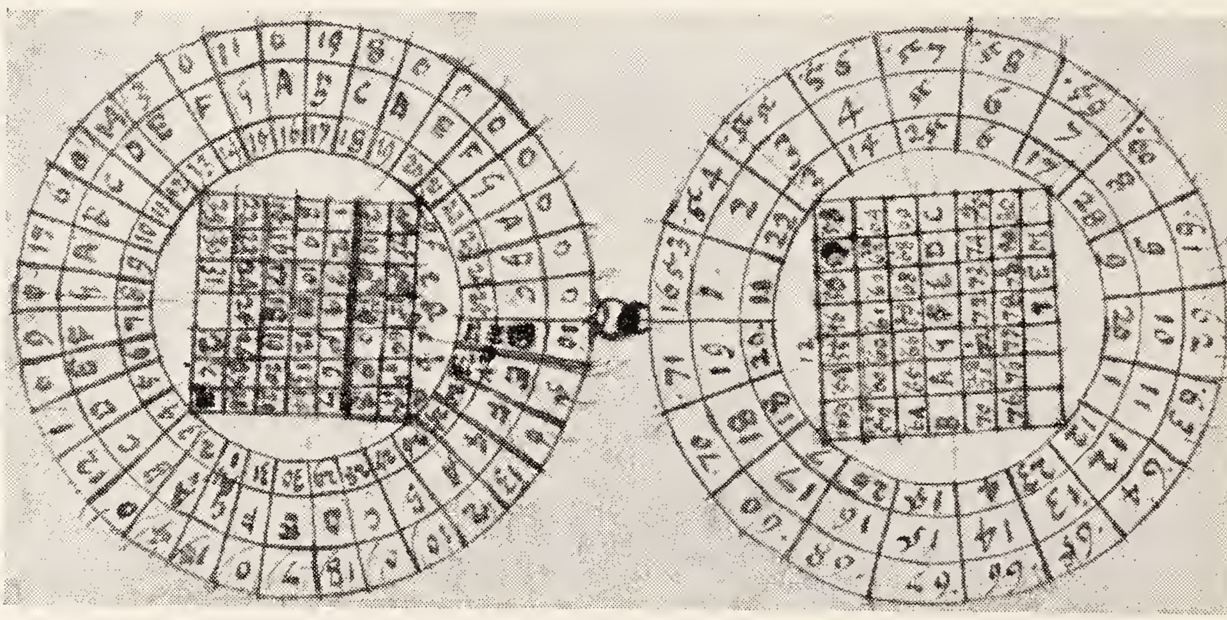
Dated 1667, 1684, 1688, 1692.

St. John's College.

Length 30 inches.

208. Perpetual Calendar. **1653.**

Lewis Evans Collection, Oxford.



'The figure of the Silver Plate sent me by Mr. Edward Mathews, B.D. of Sidney Colledge, my ever honoured friend and tutor, together with this book 1653.'

Diagram and description in manuscript, presented by Mr. S. A. Warner.

209–16. Perpetual Calendars.

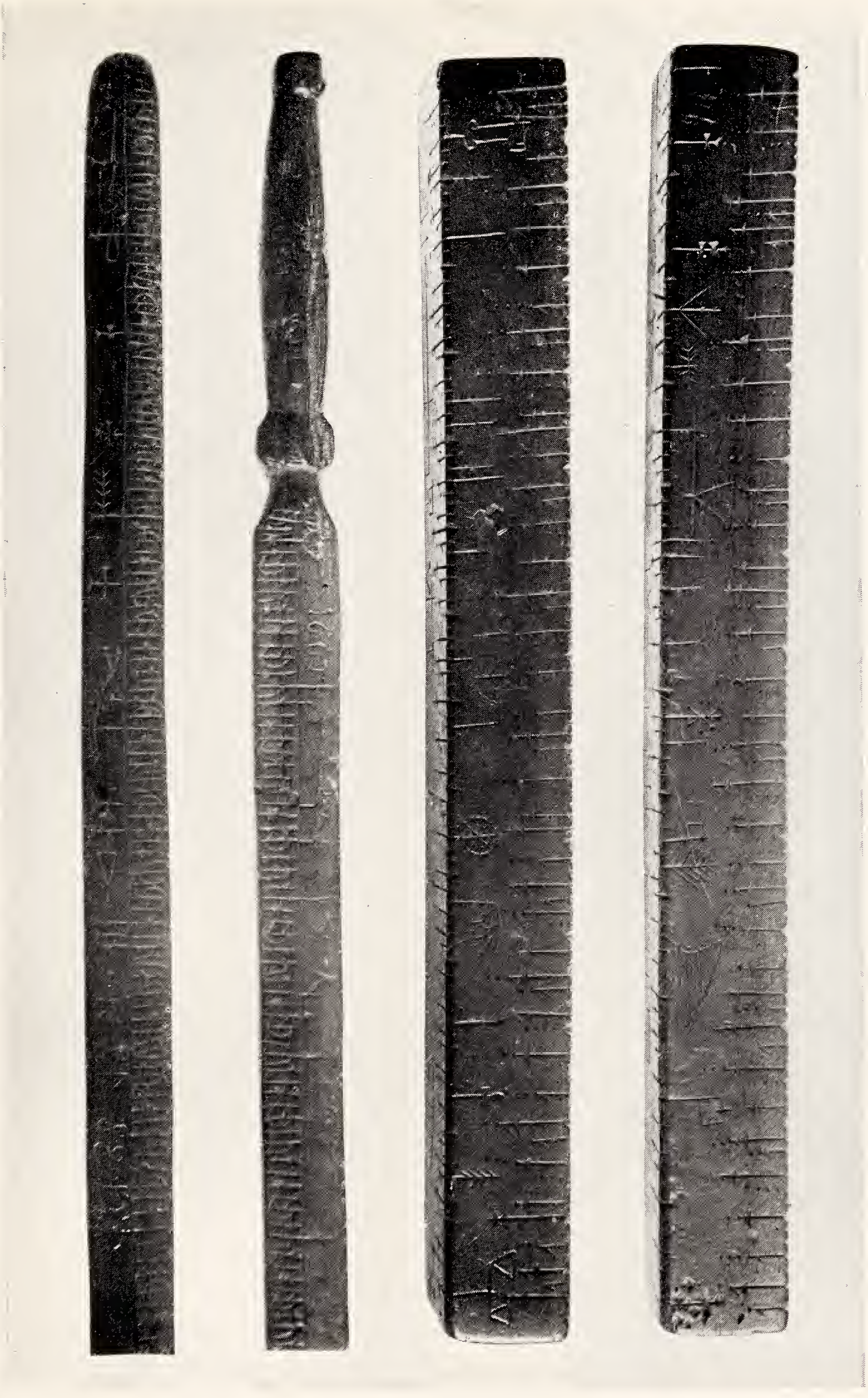
C. H.-White collection, Fitzwilliam Museum.

Five silver disc-calendars, one dated *G.G.* 1750. Three on the covers of books of ivory tablets.

217. Ivory Calendar, engraved on Case of Surgical Knives. **18th cent.**

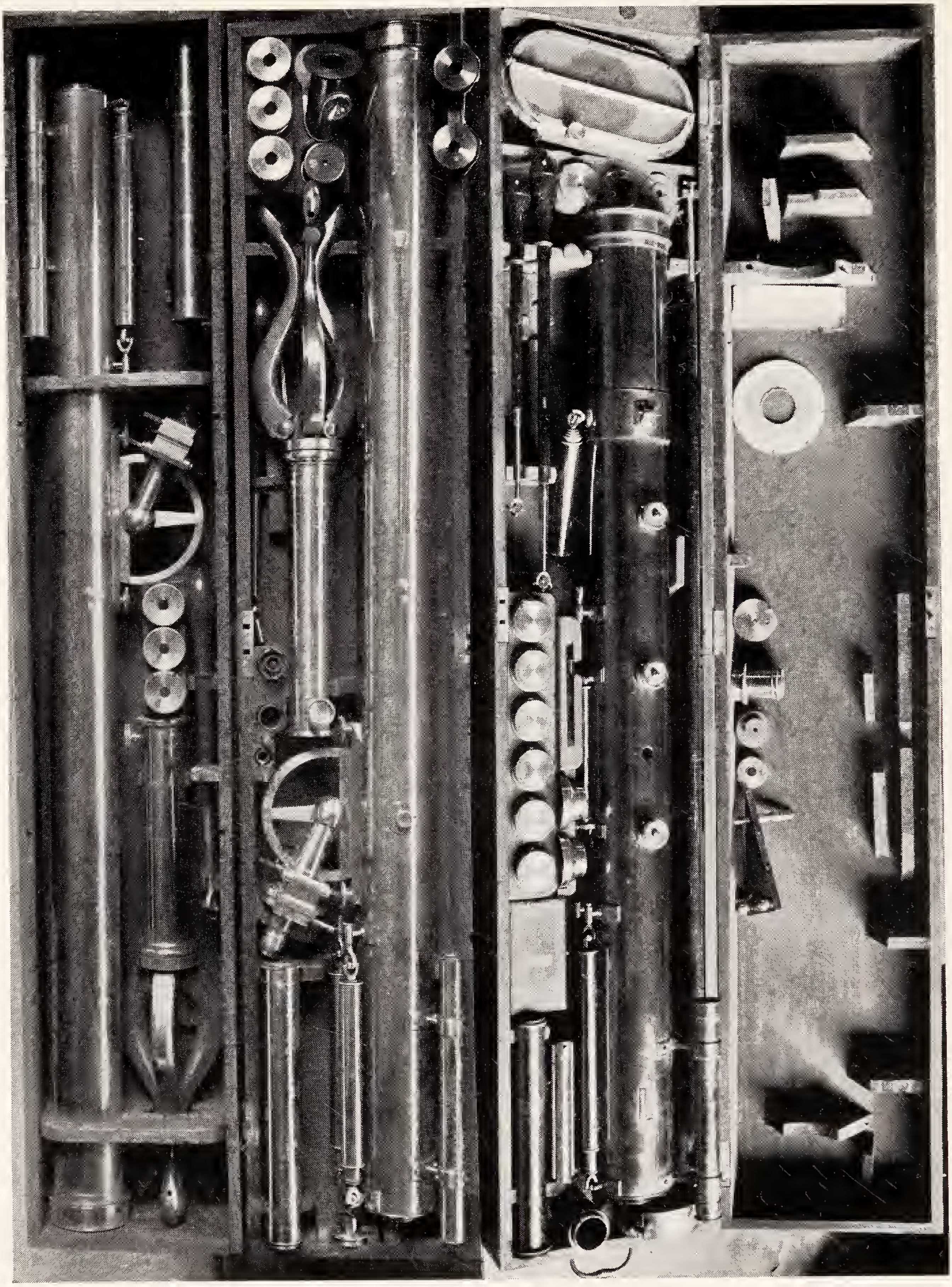
Arch. Mus.

By I. Wilkes, 57 Cornhill, London.



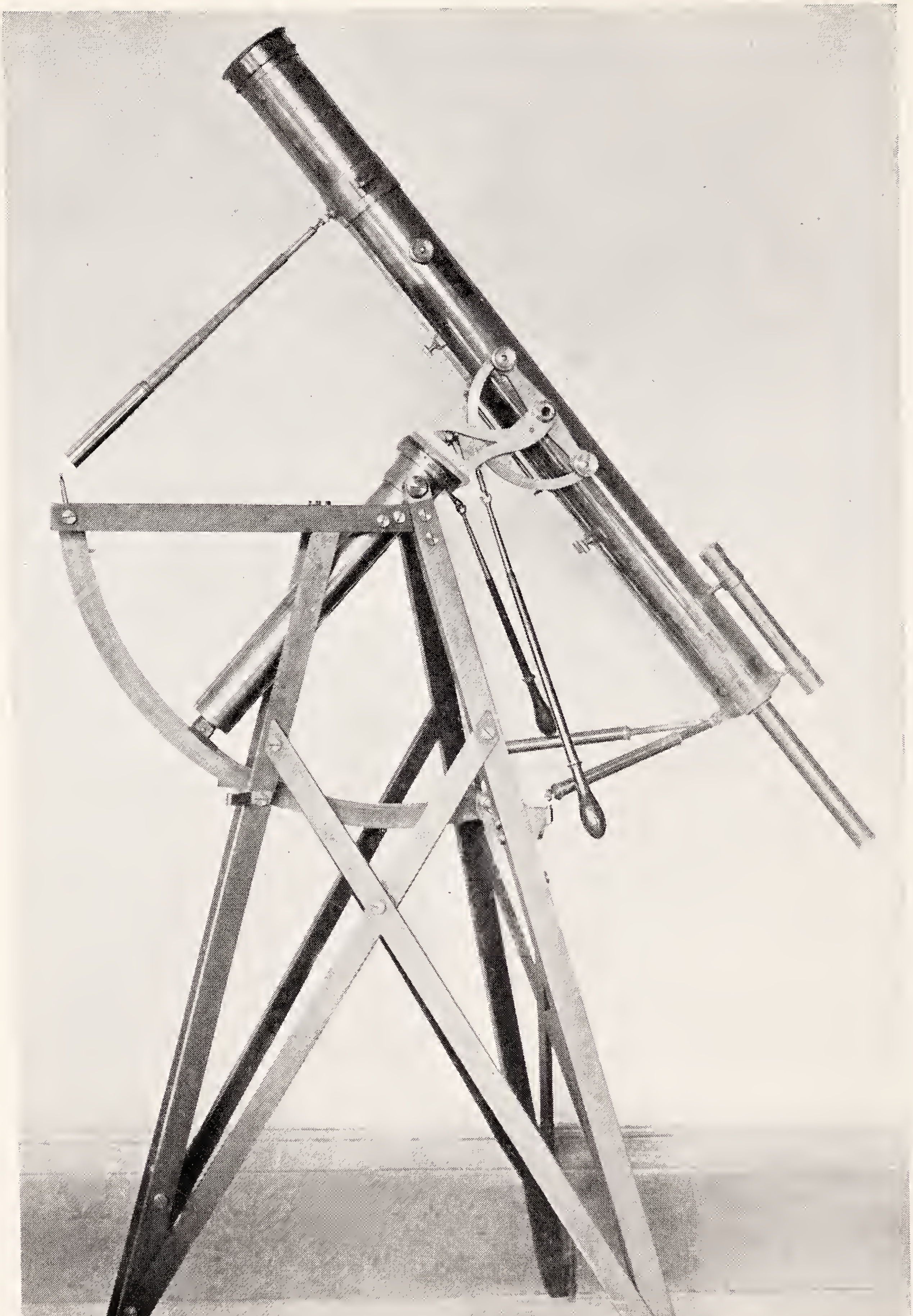
NO. 207. RUNIC PRIMSTAFF NO. 206. CLOG ALMANACK

St. John's College



NOS. 218–19. $2\frac{3}{4}$-INCH REFRACTORS NO. 220. $3\frac{3}{4}$-INCH EQUATORIAL

St. John's College Observatory



NO. 220. $3\frac{3}{4}$-INCH EQUATORIAL TELESCOPE BY DOLLOND
St. John's College

THE ST. JOHN'S OBSERVATORY EQUIPMENT

218. $2\frac{3}{4}$-inch Refracting Telescope.

St. John's College.

42-inches focus.
Probably by Dollond.

List of Fittings

6 Eyepieces.
Level.
Micrometer in box.
Cap.
Eyepiece with 6 lenses.
Cap with dark glass.
Pin (head missing).
Head of a second pin.
3 Feet for stand.
Long eyepiece.
Telescope and cap (counterpoise).
Eyepieces (4 pieces).
Polariscope.
Cap and dark glass.
Parallel edges.
Cap.

219. Dr. James Wood's Telescope.

St. John's College.

Similar to the last. A Note states the 'Aperture of Field of View' of the 3 eyepieces is as follows:

Low power 40′ of arc; middle 25′; highest power 20′.

220. $3\frac{3}{4}$-inch Equatorial and Tripod Stand.

Given by Catton to St. John's College.

By Dollond. Tube 46 inches long.

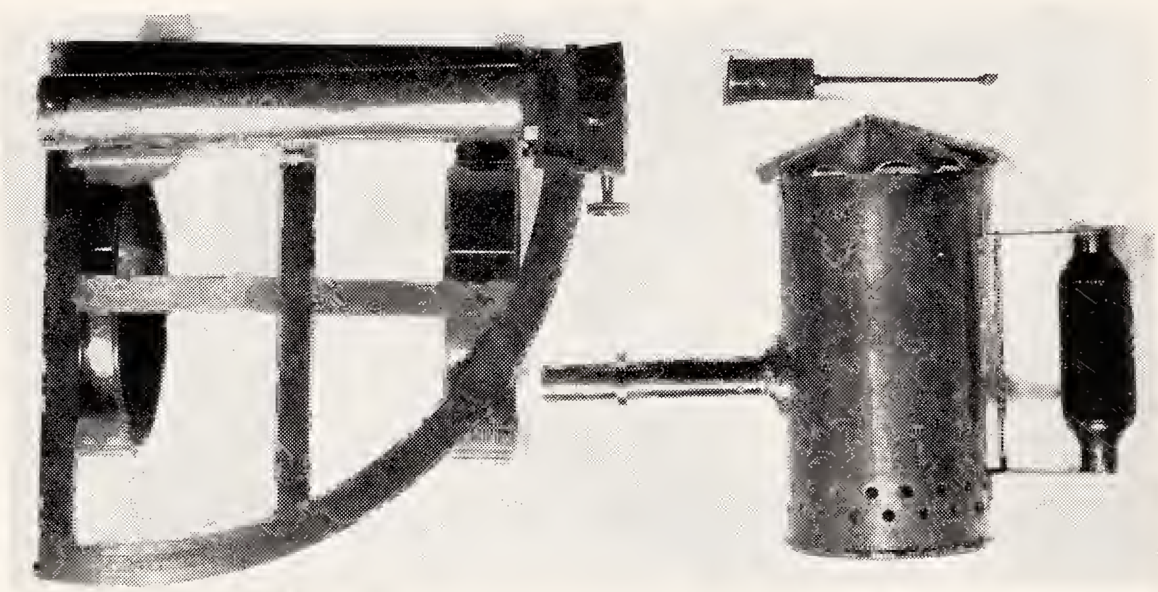
List of Fittings

Cap for Telescope.
Cap for Finder.
Erecting eyepiece.
6 Eyepieces with caps, magnification 40, 80, 120, 110, 160, 350.
Eyepiece with ring micrometer and cap and dark glass.
2nd eyepiece for ditto.
2 dark glasses.
1 Eyepiece with 5 lenses.
Divided O.G. with key.
Spirit Level.
Pin to fit eyepiece to telescope.
Lengthening tube.
2 sockets for tripod.
1 Prism.
1 Cap with dark glasses.
2 Caps.
1 Ring for counterpoise.
1 Dark plate.
4 Keys.
1 Screwdriver.
5 Handles.
Quadrant.

220 a. A $3\frac{3}{4}$-inch Equatorial.

By Dollond. Pembroke College.

Formerly in the possession of Admiral W. H. Smyth of the Hartwell Observatory. See his *Cycle of Celestial Objects*, 1860, p. 125.



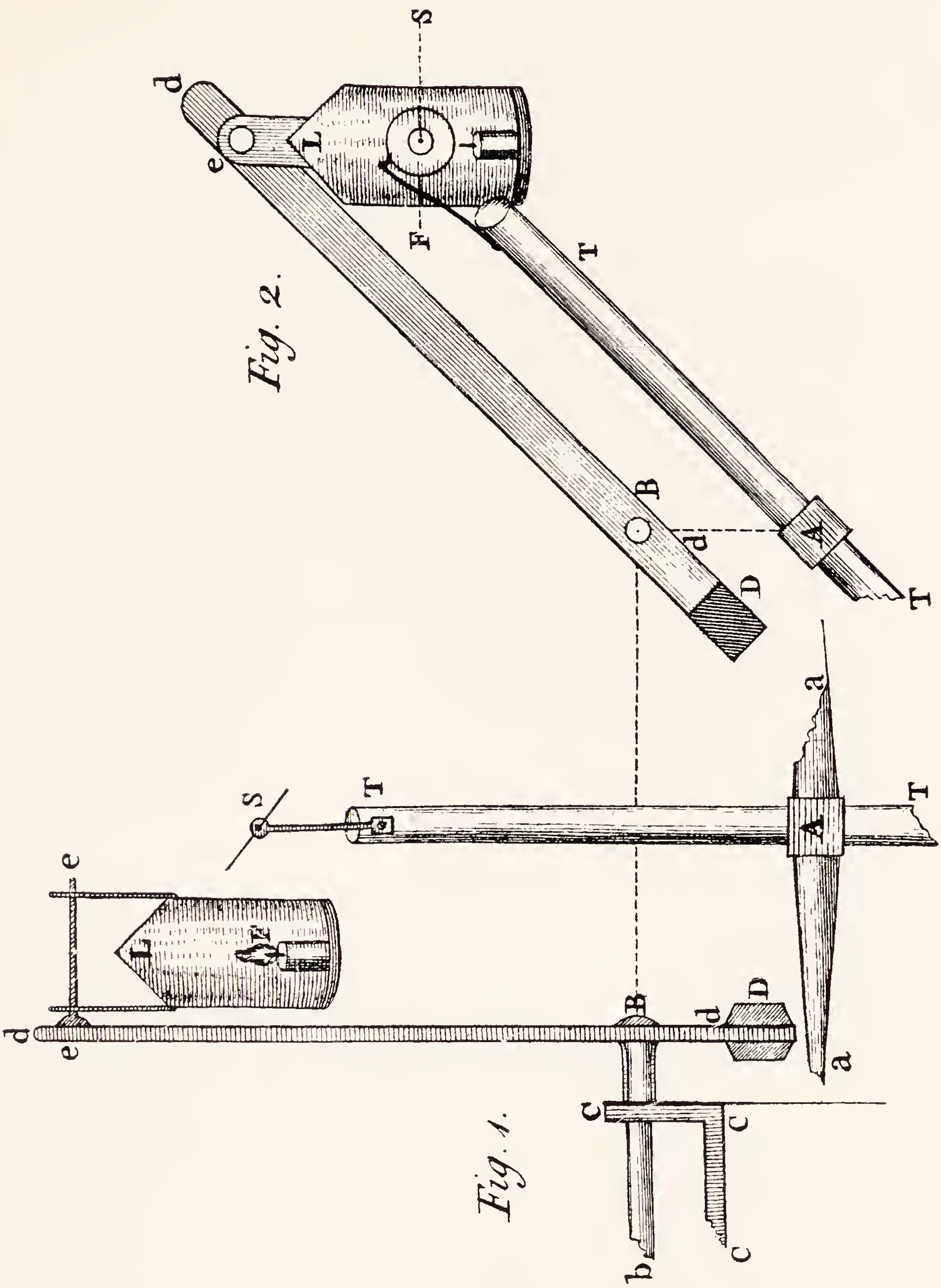
220. Quadrant and Lantern for the $3\frac{3}{4}$-inch Equatorial.

221. 42-inch Transit Instrument and Level. 1763.

Given by Dunthorne to St. John's College.

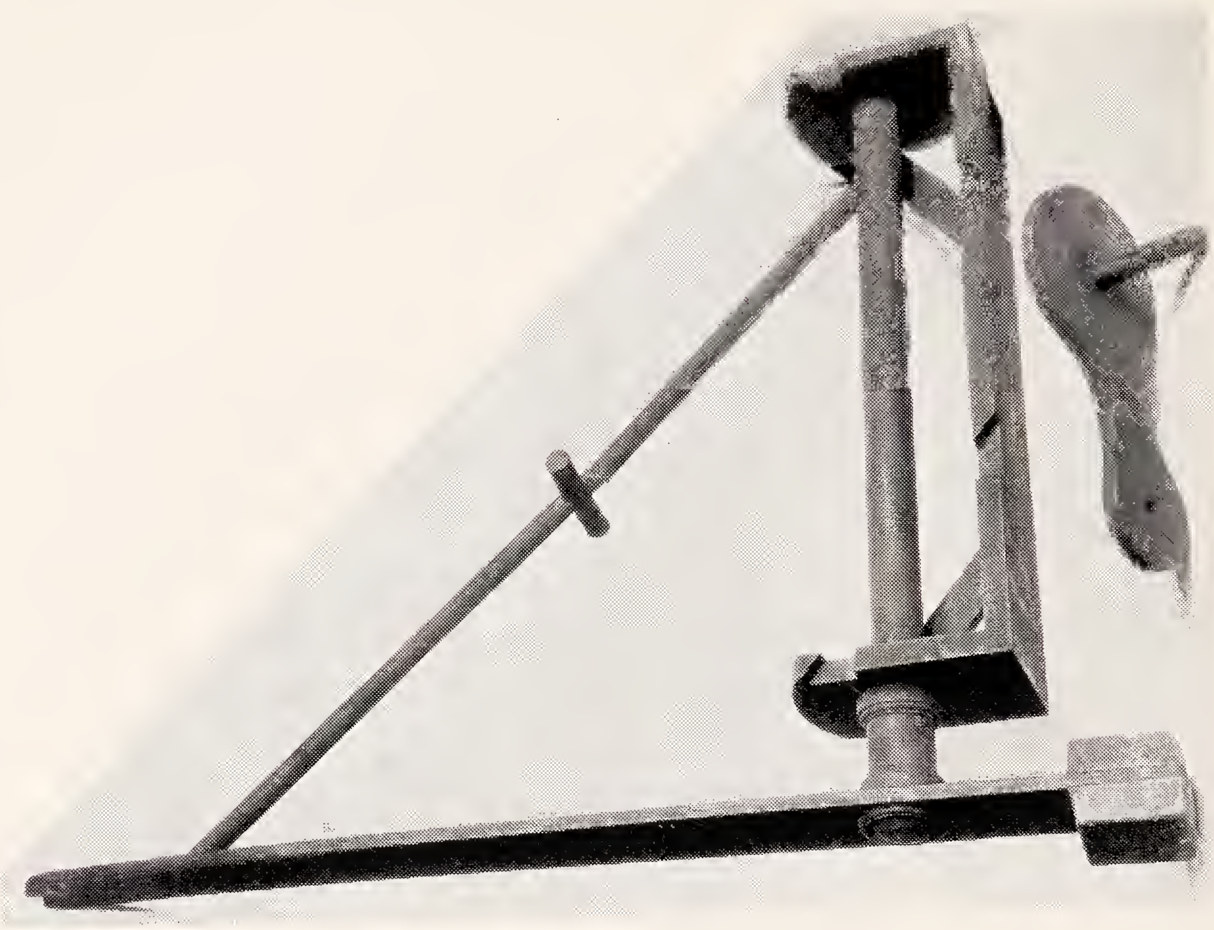
By Sisson 1763. Aperture $1\frac{3}{8}$ inches. Eyepiece pl. VI, fig. 4. Magn. ×28.

Circle 18 inches in diameter. With the instrument are (*a*) MS. table of Meridian Altitudes of the Sun for 1757. (*b*) Volume of Gardiner's Logarithms 1742, corrected by the list of errata in Hutton's *Logarithms*, London 1785, and other sources, signed 'T[homas] C[atton]'. (*c*) MS. notes of Observations made between Feb. and Dec. 1767. It is noted that in August 1769 'The center wire of the transit was left nearly bisecting the mullion [of King's College Chapel]. I[saac] P[ennington]'. Displacements were noted in 1774, and in 1785 they amounted to 'the diameter of the wire west of the true position.' This instrument remained in continual use for at least 20 years from the foundation of the observatory.



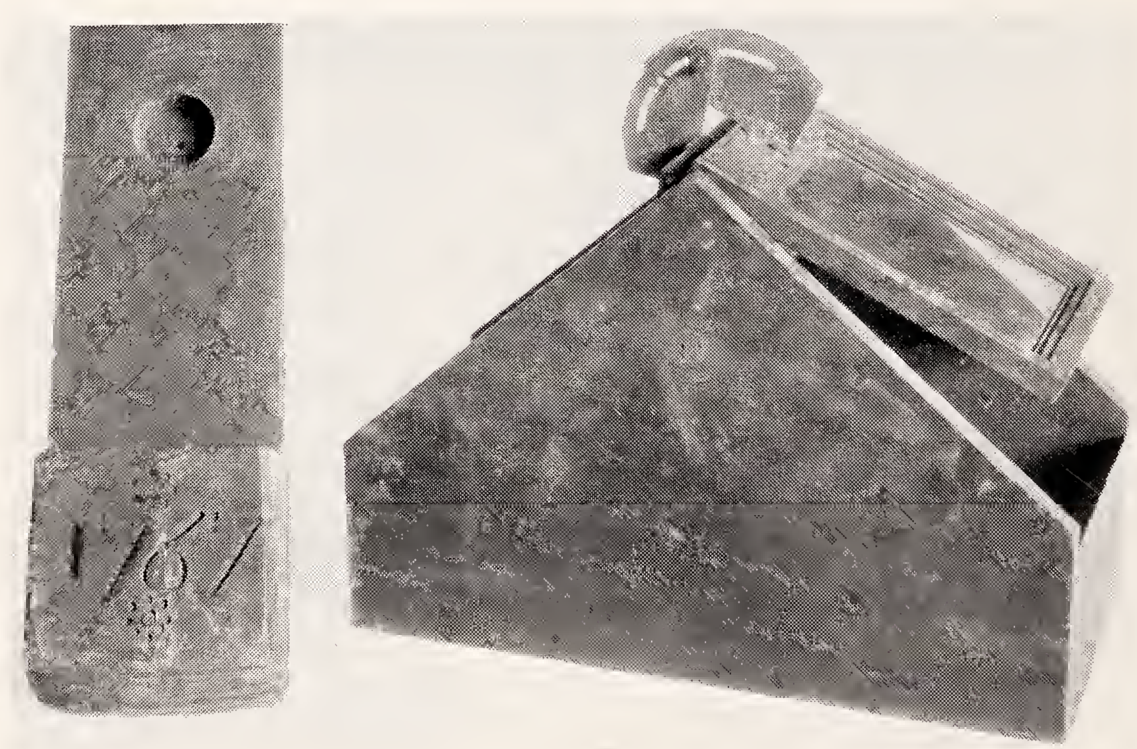
222. Ludlam's Apparatus for carrying the Lamp to illuminate the Cross-wires of his Transit.

Fig. 1. Seen from the north. Fig. 2. From the west.

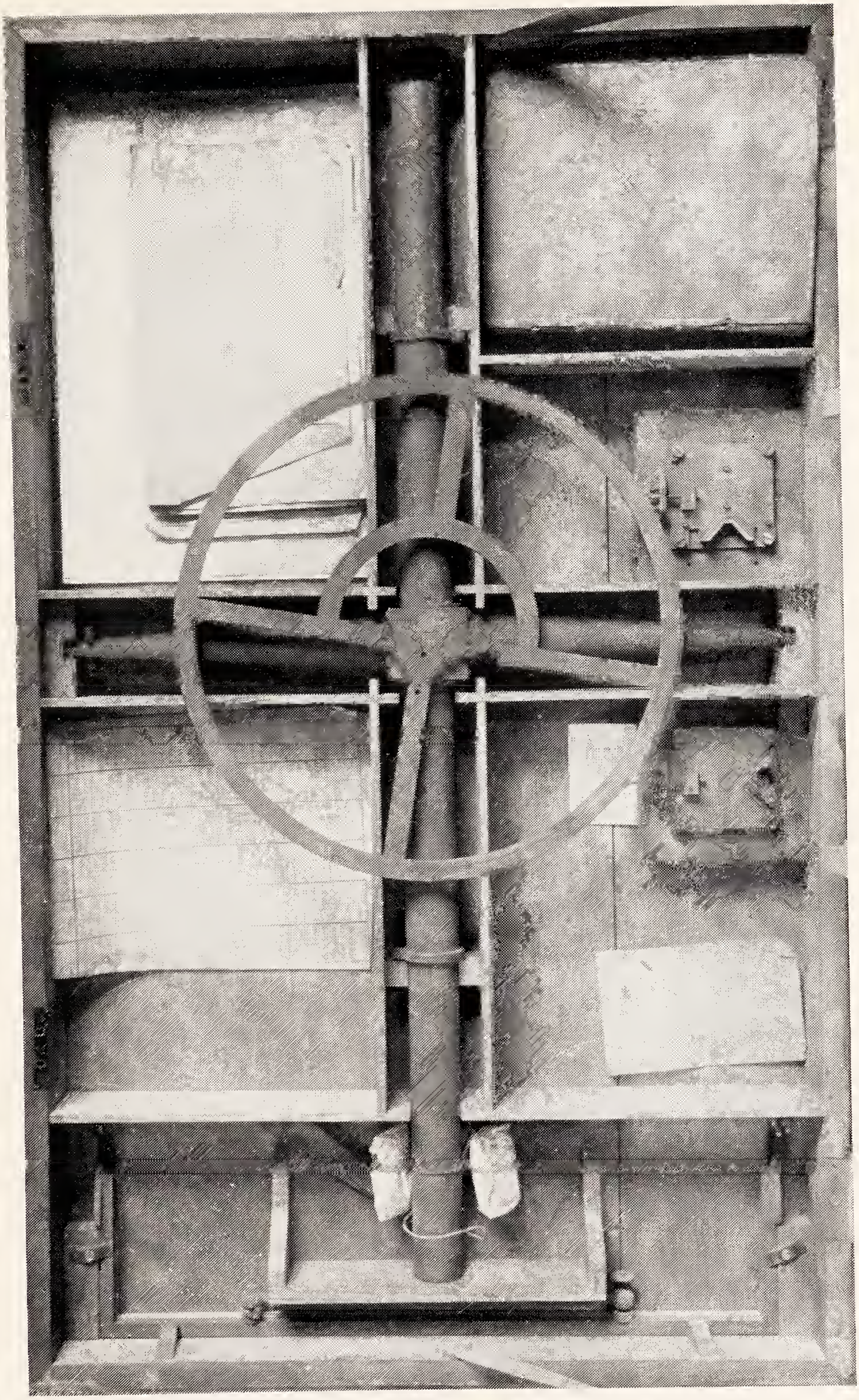


222. Part of Support for Transit Lamp. 1767.
St. John's College.

Designed by Ludlam, 1767.

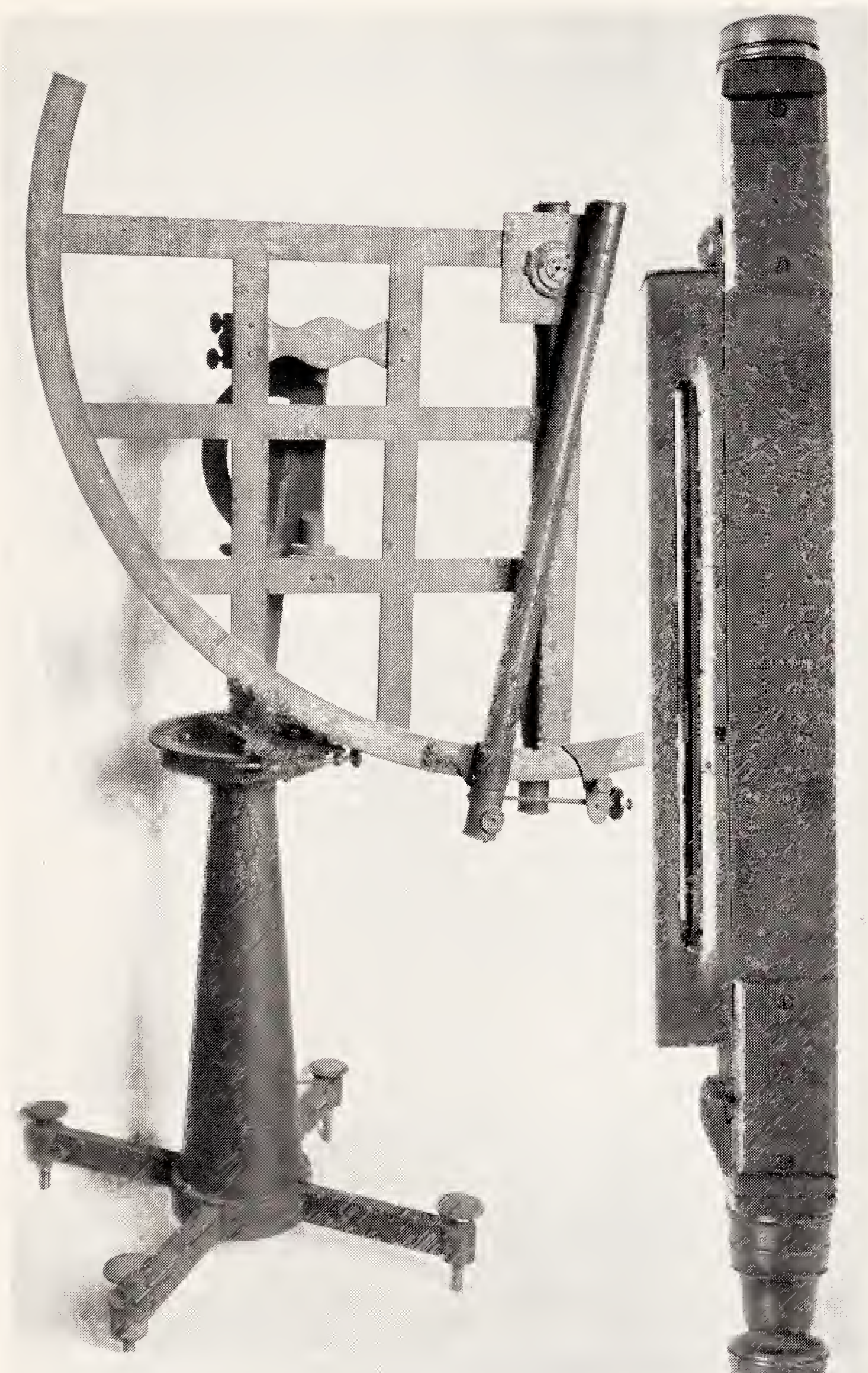


222. DATED COUNTERPOISE FOR LUDLAM'S SUPPORT.
223. COVER FOR ARTIFICIAL HORIZON.



NO. 221. 42-INCH TRANSIT BY SISSON, 1763

St. John's College



224. 18-inch Quadrant. 1765.

Given by Dunthorne to St. John's College.

By Bird, and altered by him: with two 1 ft. 10 in. telescopes. $\times 18$. See p. 170.

239. Rowley's Level. See p. 213.

Trinity College.

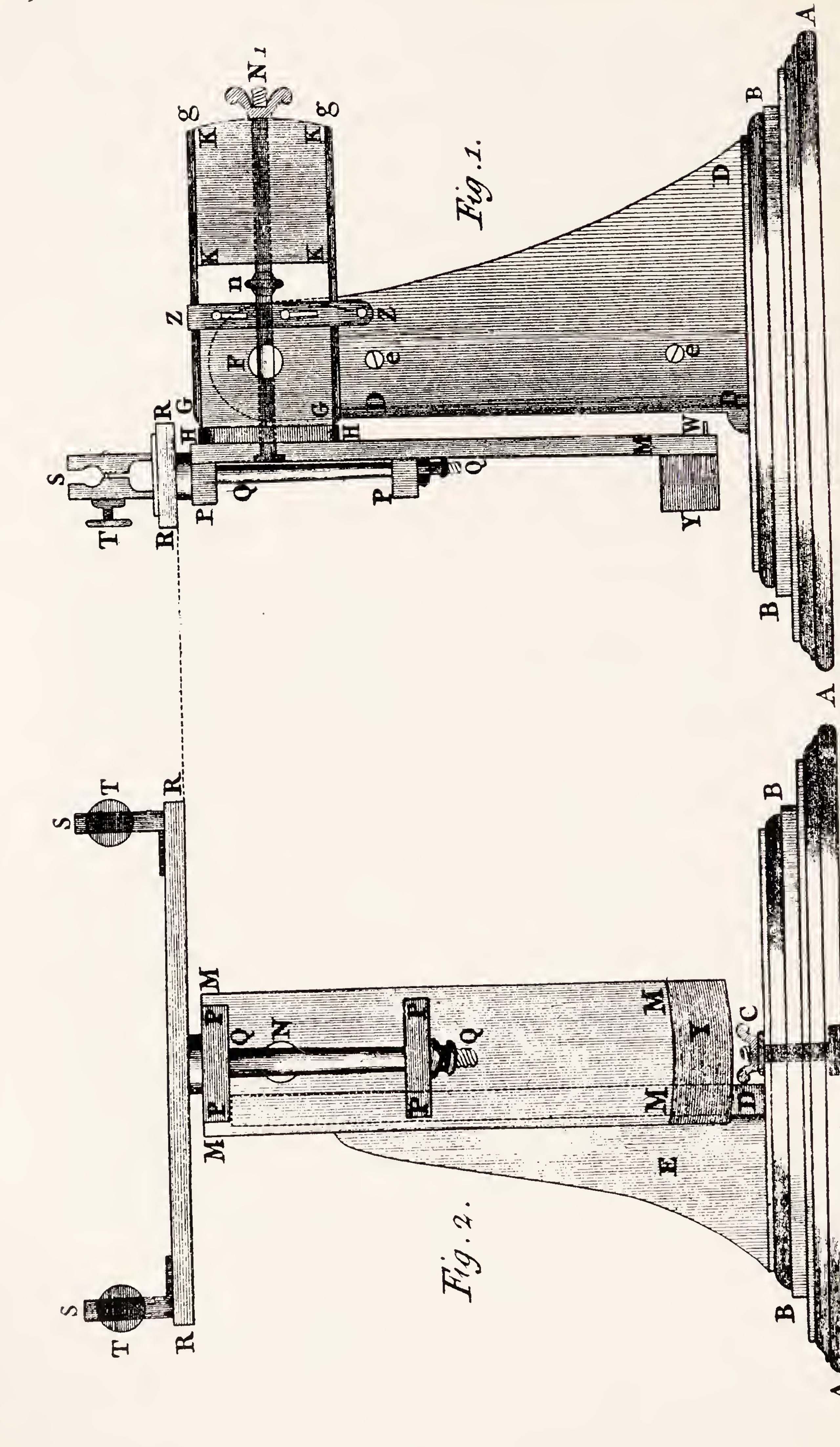


Fig. 1.

Fig. 2.

225. 18-inch Hadley's Quadrant. c. 1765.

Given by Dunthorne to St. John's College.

By Nairne, London.

225 a. Ludlam's Wooden Stand for ditto. 1767.

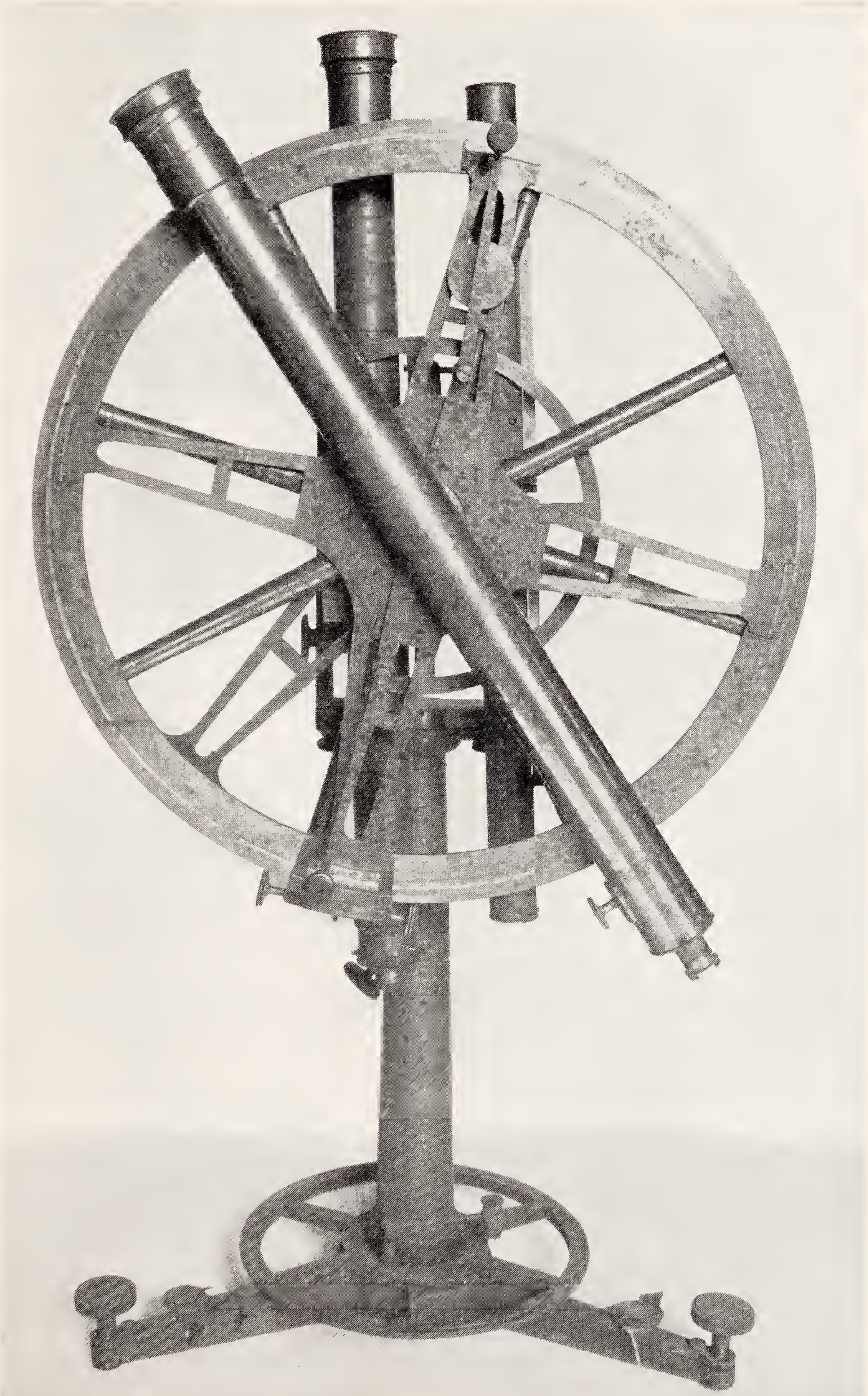
St. John's College.

Cf. p. 198.

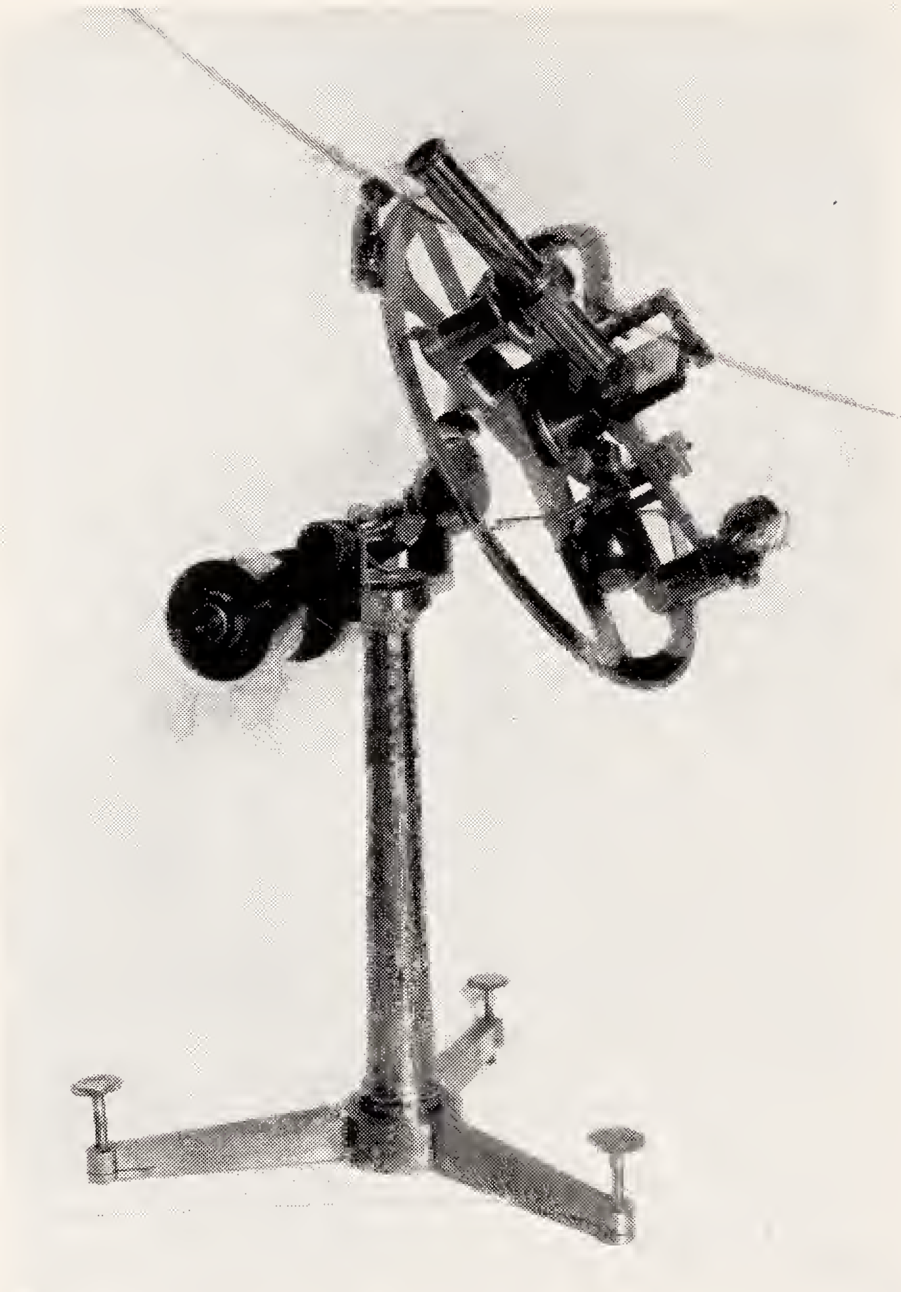
226. I ft. 7 in. Repeating Circle.

St. John's College.

By Troughton.



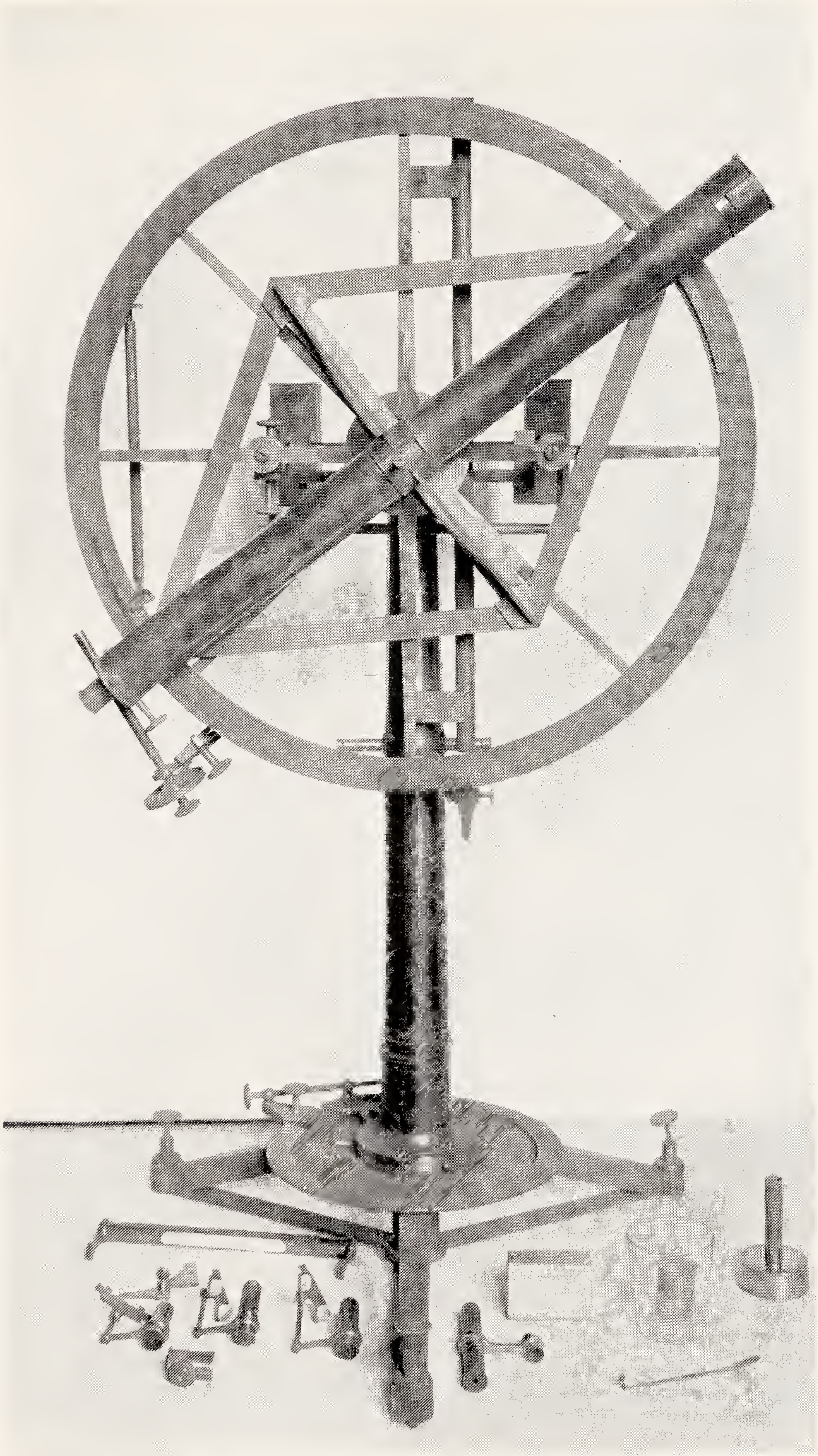
226. 1 ft. 7 in. Repeating Circle.
Given by Catton to St. John's College.
By Troughton.



227. Catton's 10-inch Reflecting Circle and Stand in 2 boxes marked 'T.C.' (= Tho. Catton).

St. John's College.

By Troughton, London, 218. See p. 171.



228. Cary's Altazimuth.

St. John's College.

1 ft. 7 in. Circle, 1 ft. 10 in. telescope, $1\frac{1}{2}$ in. OG. On stand 2 ft. high. By Cary, London.

Reflecting Telescopes

229. Small Gregorian Telescope. **c. 1760.**
St. John's Observatory.

$2\frac{1}{2}$ inches aperture.

230. Gregorian Telescope. **1763.**
St. John's Observatory.

2 ft. focal length. ×50 diam.

231. Gregorian Telescope. **18th cent.**
Fitzwilliam Museum.

1 inch aperture.

Covered with black skin decorated with silver piqué work.

232. Gregorian Telescope. **Before 1862.**
Cavendish Laboratory.

Aperture 2 inches: length $7\frac{1}{2}$ inches.

By *John Cuthbert, London,* given in 1862 by Sir James South to T. R. Robinson, father-in-law of Sir G. Stokes.

MS. note: 'Sir James South lent this to me Jan. 1862, and gave it to me in the summer of 1862. It is by Cuthbert, a famous maker of Dumpy telescopes, and defines very sharply. T. R. Robinson.'

233. Newtonian Reflector. **1671.**
Photograph of original belonging to the Royal Society.

234. 6-foot Newtonian Reflecting Telescope.
Trinity College.

Octagonal oak tube of $6\frac{1}{2}$ inches diameter, on stand 4 ft. high. 'G: HEARNE LONDON FECIT'.

Refracting Telescopes

235. 13-inch Refracting Telescope. ?$\frac{3}{4}$ inch aperture.
Trinity College.

Wooden tube with hinge. Mounts for OG and EP of lignum vitae but OG missing. Perhaps used as a level or reading telescope.

236. Part of Terrestrial Telescope.
Trinity College.

Erecting system only, in brass tube 8 inches long, 1 inch diameter.

GREGORIAN TELESCOPES

No. 229. *St. John's College* No. 231. *Fitzwilliam Museum*
No. 232. *Cavendish Laboratory*

NO. 234. NEWTONIAN REFLECTOR BY G. HEARNE

Trinity College

Reflecting Telescope made by Sir Isaac Newton, 1671.

The Solar Physics Observatory

In 1889 R. S. Newall, F.R.S., presented his great **Refracting Telescope of 25 inches aperture** and a focal length of 29½ feet to the University. The lens discs had been cast by Messrs. *Chance Brothers* and worked by *T. Cooke* of York, about 1871.

The later equipment comprises:

McClean Solar Instrument with a Double Coelostat with 16-inch mirror and 12-inch object-glass.

Huggins's Telescope and equipment.

These telescopes were used by Sir William Huggins and Lady Huggins in their observatory at Tulse Hill, 1870–1908, in researches which formed the foundation of the Science of Astrophysics. Presented by the Royal Society in 1908.

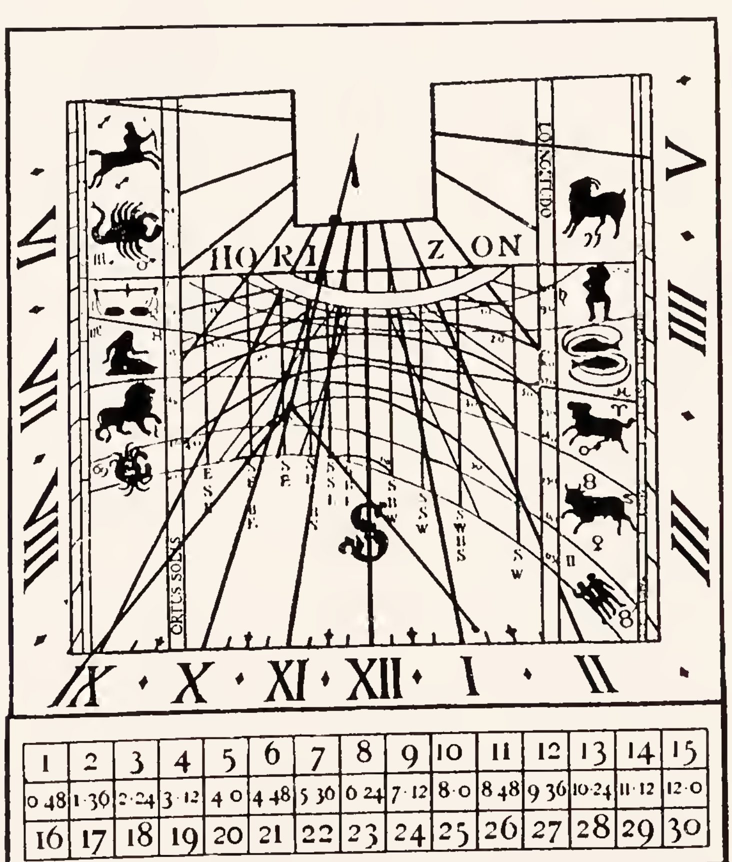
Major E. H. Hill's Spectroscope given in 1909.

Huggins's Physical Apparatus received in 1911.

Spectroheliograph for monochromatic light.

Concave grating mounted by Rowland's method.

36-inch Silver-on-glass Reflector mounted equatorially.



Queens' College Mural Dial.

VI

GEOGRAPHY AND COSMOGRAPHY

A list of the titles of the works published by early Astronomers shows that a considerable number were closely concerned with the practical application of their science to Navigation, and that many of them dealt with Cosmographical and Geographical subjects. It is no part of our present plan to enter fully into the achievements of the Geographers of Cambridge, but the following list of works by astronomical authors may be appropriately noted under a separate heading.

RICHARD EDEN (1521 ?–76), Queens', 1535–44, was living 1 Aug. 1562 at the Fold beside Barnet in the house of a friend. He died about 1576. 'He was the first Englishman who undertook to present in a collective form, the astonishing results of that spirit of maritime enterprise which had been everywhere awakened by the discovery of America.' (*Memoirs of Sebastian Cabot.*) His *Art of Navigation* was very widely used. In 1553 he translated Münster's *Cosmography* and in 1559 revised the *Anatomy* of Geminus. His other publications were:

A Treatyse of the Newe India. 1553.

The Decades of the newe worlde or West India. 1555.

The Arte of Navigation . . . written by Martin Curtes. Trans. out of Spanyshe. 1561.

A very necessarie & profitable Booke concerning Navigation, compiled in Latin by Joannes Taisnierus. [A translation of Taisner's *De Natura Magnetis.*] 1574.

CHRISTOPHER SAXTON, the father of English Chorography was of Yorkshire birth and educated at Cambridge, though at what college is uncertain. On 22 July 1577,

being servant to Thomas Seckford Esq., he obtained the Queen's Patent for the sole publication during ten years of maps of England. They seem to have been the first to be drawn from actual survey.

The engraving was partly by himself, partly by Cornelius Hogius, Remigius Hogenbagin, Leonard Tervoort of Antwerp, Augustine Ryther, Francis Scaterus, Nicholas Reynold, and William Borough. Saxton was living in 1600.

His eldest son, Robert, seems also to have followed his father's calling as a surveyor, for in 1608–9 he surveyed the lands of Heath School, Halifax. In 1613 'a plot of all the landes within the township of Mannigam' [near Bradford] was 'taken by me Robert Saxton', and in 1614 he divided the moore of Liversedge amongst the freeholders.[1]

Among the sixteenth-century writers must be mentioned Abraham Fleming (c. 1552–1607), Peterhouse, who translated *Fred. Nawse, his generall Doctrine of Earthquakes* in 1580. One had occurred on 6 April 1580.

Geo. Best, Jesus 1562, published *A true Discourse of the late voyages of discoverie for the finding of a passage to Cathaya by the North west, under the conduct of Martin Frobisher* . . . c. 1584.

Henry Cheke of Trinity travelled abroad in 1576–7.

Thomas Cavendish, C.C.C. 1576. Voyage to Virginia in 1585. Circumnavigator 1586–8. Died at sea 1592.

Wm. Parys, Peterhouse 1582, translated *John Hvigher van Linschoten his Discourse of Voyages into ye East and West Indies.* 1598.

John Farmery, M.A. King's 1568, F.R.C.P. 1588–9, author of *A method of measuring and surveying of land; publ. by J. F. practitioner in Physik.* Lond. 1589.

Edward Wright (1560–1615) of Caius translated the first account of logarithms from Latin into English. He brought a sound mathematical training to navigation, and has the honour of having defined the right method of constructing maps on 'Mercator's Projection', thereby rendering a lasting service to seamen.

A voyage to the Azores with George Earl of Cumberland gave him practical experience in 1589.

[1] *Geographical Journal,* July and August 1934.

The plane chart of early navigators was crossed by parallels of latitude and meridians spaced at equal distances, thus distorting the ratio of length to breadth, and making it impossible for a navigator to lay down a course at sight. In 1556 Gerard Mercator had appreciated the difficulty and drew a chart with the degrees of latitude roughly elongated according to a system of his own devising. But this was not being used by practical men when Wright first went to sea, and he therefore put forward a solution of his own depending on a 'table of meridional parts', constructed by himself, by which degrees of latitude are gradually increased as the latitude increases. The merits of Wright's table were perceived by Hondius in Germany and by Blundeville (*Exercises*, 1594, p. 326), both of whom adopted it. In 1599 Wright himself published *Certaine Errors in Navigation, arising either of the ordinarie erroneous making or using of the sea chart, compasse, crosse staffe, and tables of declination of the sunne and fixed starres Detected and Corrected.* 3rd edit. (see Moxon 1657), to which he added his table of meridional parts and one of magnetic declinations. The phenomena of dip, parallax, and refraction are considered, and the declinations of 32 stars are given.

The Variation of the Compass was studied in 1634–5 by John Pell, F.R.S., of Trinity. And in connexion with Longitude determination mention must also be made of the work of William Oughtred (1574–1660), of King's College.

Ben Oughtred told Aubrey that he had heard his father say to Mr. [Elias] Allen (the famous mathematicall instrument maker), in his shop, that he had found out the Longitude; *sed vix credo.* Nicolaus Mercator went to see him a few yeares before he dyed. 'Twas about midsummer, and the weather was very hott, and the old gentleman had a good fire, and used Mr. Mercator with much humanity (being exceedingly taken with his excellent mathematicall witt), and one piece of his courtesie was, to be mighty importunate with him to sett on his upper hand next the fire; he being cold (with age) thought he had been so too.

The Ebbing and Flowing of the Sea was the subject of

an interesting little book by Thomas Philipot of Clare Hall, 1632, entitled *A Philosophical Essay treating of the most probable Cause of that grand Mystery of Nature, the Flux and Reflux or Flowing and Ebbing of the Sea.* 1673, and dedicated to the learned and judicious Sir John Marsham of Whoorney Place in Kent:—

Sir,

When the Sun opens the curtains of the East, and gilds and enamels the fringes of the firmament with his early beams, the lesser lights resign themselves up to his, and muffle themselves up in their own obscurity, as being vanquished with an excess of splendour; so the meaner and pettier censures shall look faint and dim, if you, that are the great luminary in the orb of Learning, shall shed a propitious beam and influence upon this crude essay; which will not only rescue it from the virulency of detraction, but so foment and improve it, that it will bourgeon and flourish under your protection. So that, though it owe its birth to my pen, it will intitle its verdure and perfection to your candid acceptance of it; now it is offered up to yours, from the hands of him who is

Sir,

Your most affectionate Servant

Thomas Philipot.

The provision of 'A nursery of children to be educated in Mathematics for the particular use and service of navigation' was a matter in which Samuel Pepys took the keenest interest while he was at the Navy Office. The King, too, realized the importance of such training, and promised an endowment of £1,000 a year for seven years for a Mathematical School in connexion with Christ's Hospital, in which appropriate instruction should be given. Mr. Leake was appointed headmaster, and Hooke was commissioned to design a badge. The discipline soon slackened, and a Dr. Wood, 'to cover his idleness', farmed the boys out to one Hudson, 'a kind of mathematical curate' and a 'drunken fellow' (Pepys, 1681).

Richard Franck (*b.* Cambridge, temp. James I), publ. *Northern Memoirs, calculated for the Meridian of Scotland, Wherein most or all of the Cities, Citadels, Sea-ports,*

Castles. . . . Writ in the year 1658, but not till now [1694] *made publick. . . .*

The construction of instruments for making accurate measurements and also suitable for use at sea had only become perfected towards the close of the 17th century, and so navigational methods were largely crude, e.g. confined to the use of the eyes and sounding-lines.

In 1700 NEWTON sent to Halley a design for an instrument for measuring angles, but the invention was not published until thirty years later when Hadley reinvented it!

Thanks to the perfection of the Sextant and of other measuring instruments, the exploration of the world began to take a definitely scientific turn. And whereas the older explorers had merely added new lands to the map, Captain Cook, sailing under a commission from the Royal Society, undertook a 'scientific' expedition of discovery.

CHARLES MASON, D.D., of Trinity College made a trigonometrical survey to which Mr. Arrowsmith gave a corrected outline and Mr. W. Custance of Cambridge rectified the courses of Rivers and Roads in the southern part of the County. The result was published in Lysons, *Britannia*, 1808.

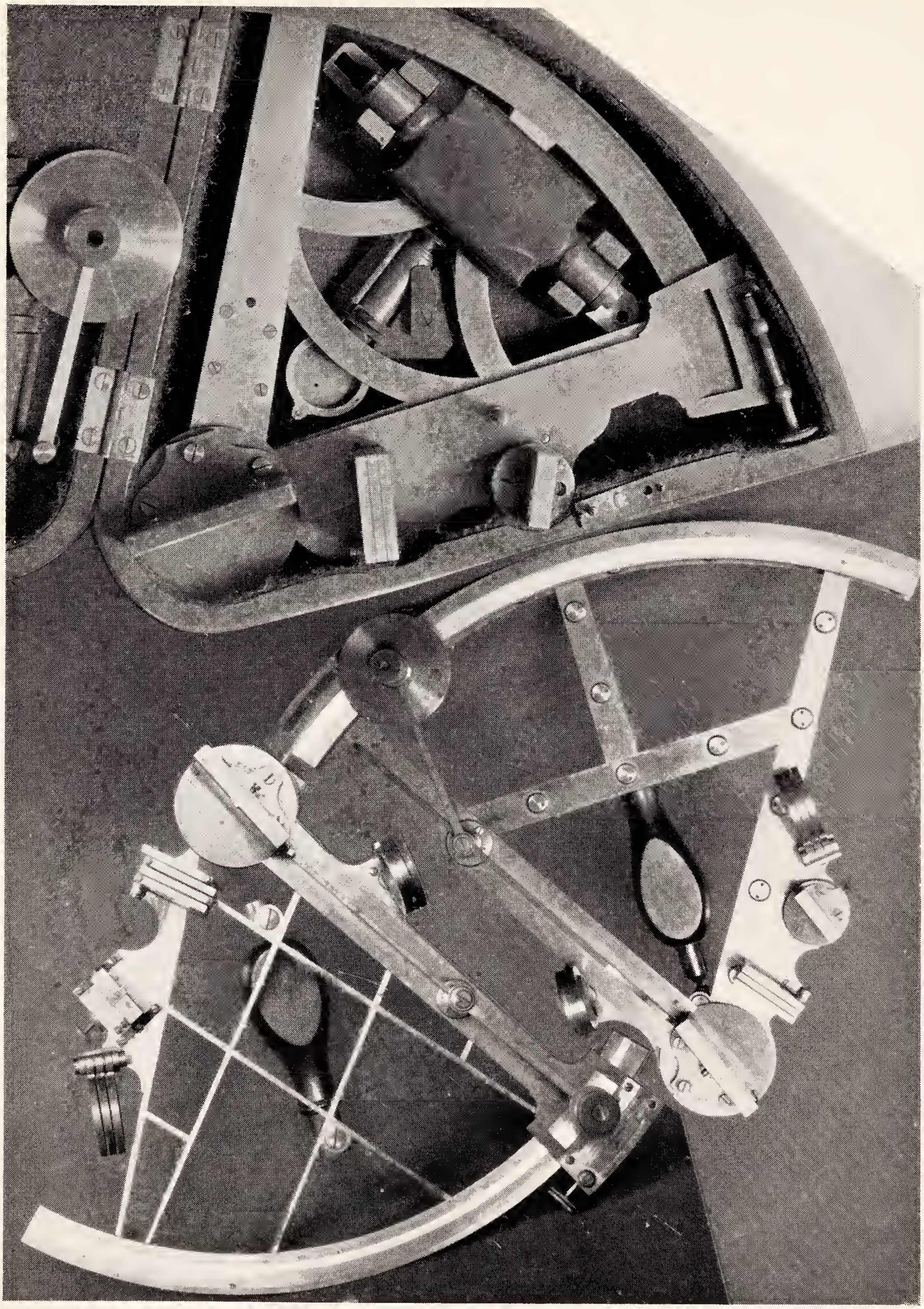
In 1813 THOMAS YOUNG contributed an important essay on the Theory of Tides to *Nicholson's Journal*, and this was followed in the early thirties by the Rev. Wm. WHEWELL of Trinity College whose first results were the memoirs and map of cotidal lines, contained in the *Transactions of the Royal Society* for 1833.

To come to more modern times, the seiches which occur in the Scottish lochs were investigated by GEORGE CHRYSTAL when nearing the end of his life.

PROFESSORSHIP OF GEOGRAPHY

1. FRANK DEBENHAM 1931

A Map I made at Cambridge, for Rays *catalogus p. c. Cantabrigiam* when I went a simpling with Stephen Hales, Geo. Rolfe &c 1705 [In Stukeley's handwriting.]



SEXTANTS

No. **241.** *By E. Nairn*

No. **244.** *By W. & J. Jones* No. **242.** *By Troughton*

SURVEYING INSTRUMENTS

237. Brass Triangle and Plumb Level.

In Roger North's Instrument Box. See p. 50.

238. Four French Folding Squares and Plumb-levels. **18th cent.**

(*a*) By *Butterfield*. 'Demi pied du Rhin.' Arch. Mus.
(*b*) By *Langlois*. 'Demi pied du Roy.' ,,
(*c*) By *Clerget*. ,, ,, ,,
Ruled with a '*ligne d'aplomb*'.
(*d*) By *Le Maire fils*. Holden-White Collection.

239. 12-inch Spirit Level. See p. 197. **1703.**
Trinity College.

'I. Rowley Fecit'. 'Colleg. Trinit. Cantab. 1703.'

The square telescope tube appears to have been mounted on a semicircle (now lost). The shape of the eyepiece is like those turned in wood by Marshall: it is fitted with a cross thread, and like the object glass is provided with a cap. The spirit-level with red fluid is 6 inches long.

240. 18-inch Octant. **c. 1750.**
Prof. A. Hutchinson.

By 'John Rutledge'.

241. 7-inch Sextant. **c. 1770.**
St. John's College.

By 'Edw^d Nairn London.'

242. $11\frac{1}{2}$-inch Sextant. **Period c. 1790.**
Cavendish Laboratory.

By 'Troughton, London.'

243. $13\frac{1}{2}$-inch Sextant. **c. 1790.**
Mineralogical Museum.

By 'Ripley & Son, Hermitage Bridge, London.'

244. 8-inch Sextant. **Period 1793–1822.**
Cavendish Laboratory.

By W. & J. Jones.

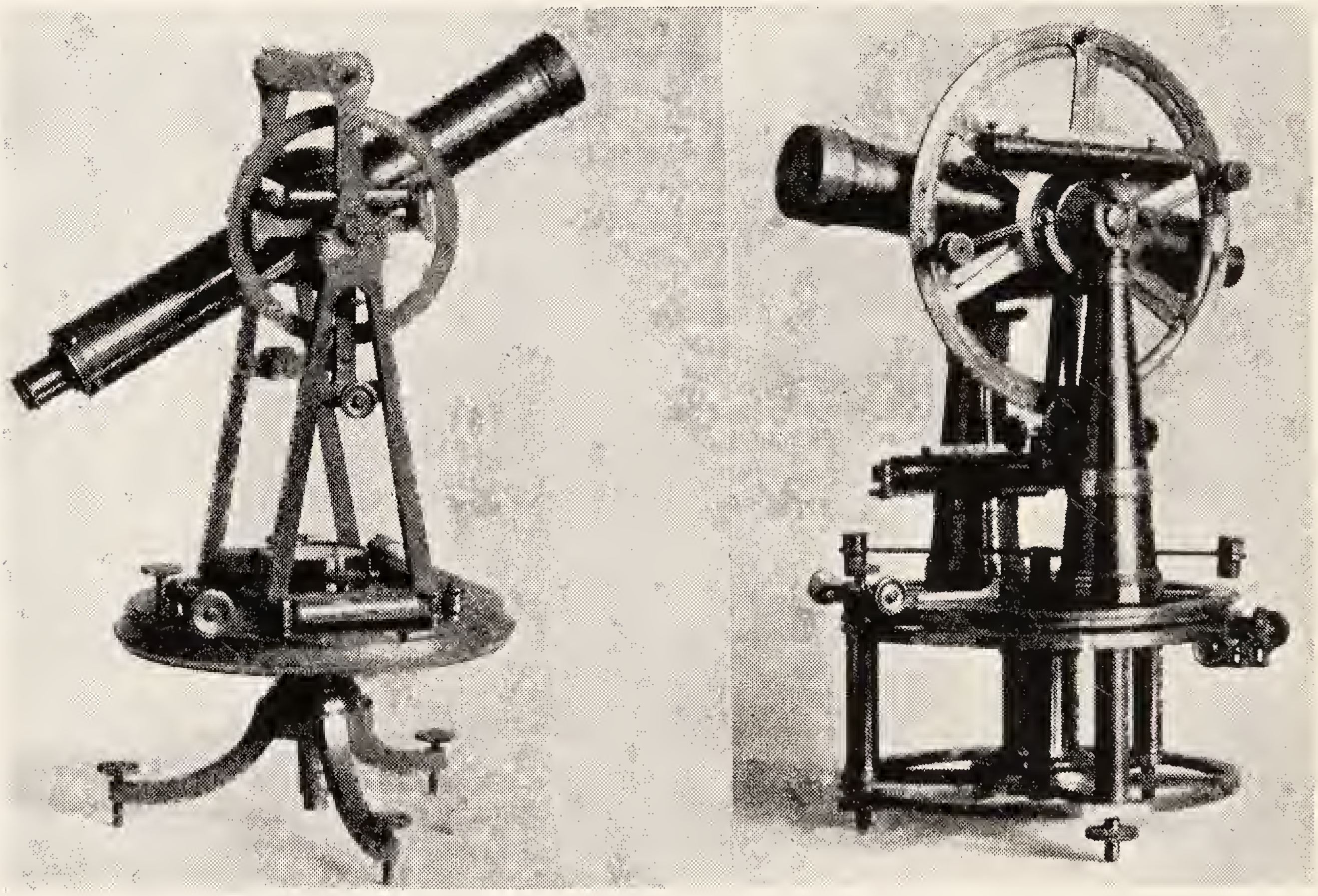
244 a. 8-inch Sextant. **19th cent.**
Mineralogical Laboratory.

By 'Dombey & Son London' and 'W. & F. Gilbert London'.

245. Theodolite. **c. 1800.**
Cavendish Laboratory.

By '*Thomas Jones Charing Cross London*'.

Telescope: length $10\frac{1}{2}$ inches; $1\frac{1}{8}$ inches aperture. Diam. of horizontal circle $6\frac{3}{4}$ inches; diam. of altitude circle $3\frac{3}{4}$ inches. $1\frac{1}{2}$-inch compass box.



No. 245. No. 246.
THEODOLITES IN THE CAVENDISH LABORATORY.

246. Theodolite. **c. 1800.**
Cavendish Laboratory.

By '*Thomas Jones & Sons* 62 *Charing Cross London*'.

Telescope: length 12 inches; $1\frac{3}{4}$ inches aperture. Diam. of horizontal circle $8\frac{1}{2}$ inches; diam. of altitude circle $7\frac{3}{4}$ inches.

VII

METEOROLOGY

William Kenningham or Cuningham, who matriculated at Corpus in 1551, and after 1563 lectured on medical subjects in London, was an almost encyclopaedic writer on many subjects. According to his own statement in his *Cosmographicall Glasse* 1559, he had, but probably only in manuscript, a Commentary on a work of Hippocrates, *De Aere, Aquis et Regionibus.* The note is not of great importance except in that it quotes one of the fountain-heads whence issued the Meteorological knowledge of the day.

A compelling interest in unusual happenings was fomented by such writings as that by Abraham Fleming, who matriculated at Peterhouse in 1570, entitled *A Straunge & Terrible Wunder wrought very late in the Parish Churche of Bongay* 4 Augt. 1577, *in a great tempest of violent raine, lightning and thunder the like whereof hath been seldome seen. With the appearance of a horrible-shaped Thing, sensibly perceived of the people then & there assembled.* 1577, repr. 1826. He wrote on the Comet in the same year.

John Farmery, M.A., King's 1568, F.R.C.P. 1588–9, is believed to have been the author of *Perpetuall Prognostication of the Weather* by I. F. Lond. 1590.

We owe to the Hon. Roger North's *Autobiography* an interesting account of the use of the Barometer about 1680.

Our conversation was much upon music and philosophy. Our brother John, who was a Cantabrigian and very ingenious as well as learned, gave much life to our entertainments; for he was excellent at sparring doubts, and reserved himself to be moderator of our disputes, which would be sometimes very warm. I remember once we had a hot dispute about the barometer, and the reasone of its keeping time with the weather, and agreed to put our sentiments in writing and to send them

to Oldenburg of the Royal Society[1] to be printed, and he returned them all, which made my brother Francis laugh and say his fared ill for being in such company. I thought then, and do still, that I was in the right, and have set forth the matter at large in my discourse on the *barometer*, which had its start from this controversy. My brother Francis went on the common notion of vapours, but made them heavier when low and ready to rain than when high, as all gravity is less far from than near the surface of the earth. I battled these vapours, and persisted that the common air was water or vapour, and that heats and colds intermixing swelled or shrunk the atmosphere by producing the effects of fair weather or rain, and that influenced the mercury.

'I was up and down Fleet St. to inquire of the wether-glass you bought . . . near Serjeants Inn, but I can hear no tidings of it.' Wm. Hayhurst to R. Kenyon, 1683 July. H. M. C. Kay on MSS. 533. Sir S. Morland's barometers were not sold in shops until Lord Keeper North encouraged it. *Lives of the Norths*, i. 384–8.

The greatest storm 'ever known in England' is said to have occurred on 26 Nov. 1704, when

'Part of King's College Chapel fell down; part of Katharine's Hall's New Chapel was damnified; Fifteen stacks of chimnies fell down into St. John's College, without hurting anybody, but 2 or 3 miraculously escaped. St. Peters College was much damnifyed & a stack of chimnies fell into the Vice Chancellor's chamber, but was so far from hurting that he was not awaken'd by it.'

Stray notes on the weather show that Stephen Hales kept a Journal of the Weather, e.g.: '1756 June 7, the wind S.W. cloudy, the thermometer at 58 degrees.' Ever seeking quantitative knowledge, he also experimented on the amount of rain and dew on special areas of ground.

An Anemometer, for measuring the force and direction of the wind, invented by Whewell in 1834, was used for a few years by Professor Phillips at York.

Appalling thunderstorms are recorded for 9 August 1843, when scarcely a house, college, church, &c., escaped without injury.

[1] Henry Oldenburg, for some time Secretary of the Royal Society, died in August, 1678.

'THE ALCHEMIST' BY DAVID TENIERS

From the collection of Sir W. J. Pope

With Compliments

W. J. Pope

VIII

CHEMISTRY

Certainly a few of the early students at the University may reasonably be assumed to have acquainted themselves at least with descriptions of the methods which had been employed by Geber and other Arabian chemists, even though the stern early scholastic régime of Cambridge may not have permitted them to practise so black an art. Collections of Alchemical Tracts, such as are contained in MS. 2110 in the University Library,[1] comprising a selection of the works of Arnold de Villanova and Ripley, and illustrated with drawings of furnaces and stills, clearly point out the roads to such knowledge as was available at the commencement of the period of Iatro-chemistry (1499–1627), when belief in the alkahest, the universal solvent of Valentine, began to give way to the theories of Paracelsus and the practical teaching of Agricola.

To this period belong three Cambridge chemists.

The earliest of these, Samuel Norton (1548–1621) was the great-grandson of Thomas Norton, the alchemist of Bristol, whose *Ordinall of Alchimy* was well known. Samuel came up to St. John's in 1577; became Sheriff of Somerset in 1589–90; and died in 1621 (will P.C.C.). He wrote:

1. *The Key of Alchemie.* MS. Ashmole 1421, art. 26.
2. *Ramorum Arboris Philosophicalis libri tres.* MS. Ash., 1478.
3. *Catholicon Physicorum.*

[1] Cf. also MS. 220, xvi cent.; MSS. 1255–6 of Robert Greene and MS. 1388 given by John Rant of Caius College in 1655. Some early diagrams of chemical apparatus are drawn on leaves from a 13th-cent. MS. of Philo, *De Subtilibus Ingeniis*, belonging to Pembroke College MS. 169. See also MS. Caius 181 (15th cent.).

4. *Mercurium redivivum.* Published in 1630 with the preceding work by Edmund Deane, M.D.

Next came the noted JOHN DEE, also of St. John's College, some of whose more remarkable contacts are recounted on page 143. He had an alchemical laboratory at Mortlake, where with the philosopher's stone he converted a piece of metal out of a warming pan into silver, which he sent to Queen Elizabeth. About 1583, when he was abroad, the mob broke into his house and destroyed furniture and chemical apparatus which had cost him £200. Some of his 'secrets' were inherited by his son, Arthur, and so by Elias Ashmole, who was thereby influenced to found a Chemical Laboratory in the Old Ashmolean at Oxford.

A chemist of a more practical turn was WILLIAM PARYS of Peterhouse, 1582; M.A. 1589; master of St. Olave's School, Southwark, 1595–†1609. To him we owe:

A booke of Secrets: shewing divers waies to make & prepare all sortes of Inke & Colours: as Blacke, White, Blew, Greene, Red, Yellow and other Colours. Also to write Gold & Silver, or any kind of Mettall out of a Pen: with many other profitable secrets, as to colour Quills and Parchment of any colour: and to graue with strong Water in Steele and Iron.

How far later chemists of the first half of the seventeenth century were successful in their search for chemical secrets by which money might be made, we do not know. But the Domestic State Papers show that industrial chemistry of a sort was being carried on at a loss. For instance, about 1635 one Stephen Barrett of Cambridge was 'saltpetre man', and his duty it was to carry one load of saltpetre liquor for the King's service. We know this because it was found on 14 July that he had failed to produce his quota.

On 7 April 1636, according to another document, Hugh Grove, saltpetre-man, petitioned the Lords of the Admiralty, stating that he had been forced to erect a work at Cambridge which cost him £200, and now cannot obtain the services of carts and teams to carry his liquor. Eventually on 10 October 1637 David Stevenson was appointed to make saltpetre.

The importance of this primitive and long forgotten industry may be gauged from the following considerations:

Gunpowder was first manufactured in England in 1412. For early artillery it was used in its mealed state, and was called 'Serpentyne Powder'. It is recorded that in 1415–16 the ingredients, saltpetre, 'brymstone', and other necessaries were purchased by Gerard Sprong; and by subsequent orders their exportation was prohibited.

A 16th-century patent was granted to John Powell, the Surveyor of Ordnance, for the making of salt-peter. (Copy in Lansdowne MSS. 113. 59 in B.M.)

In 1595 a Proclamation was issued for the calling in and frustrating all Commissions for the making of Salt-peter granted forth before that to George Evelin & others the 28 of January 1587, whereby many of her Maiesties subjects were greatly abused; as also all that made peter by the said Commission doe bring the same into her Maiesties store &c.

Again, on Dec. 24, 1624, there was a further 'Proclamation for the preseruation of Grounds for making of Salt-Peeter, and to restore such Grounds which now are destroyed, and to command assistance to be given to his Maiesties Salt-Peeter-makers'. This Proclamation was repeated in 1625 and in 1635, when non-attention to the proclamations of 1624–5 made it necessary to again publish a new one so that none might plead ignorance. It forbids the paving with stone, brick or floor-boards of any dove cot, outhouse, cellar or vault (except only that part used for wine or beer), or laying the same with lime, sand, gravel or anything which would stop the growth of the 'Mine of Saltpeter'.

On 2 July 1666 John Evelyn was informed of his nomination as one of the Commissioners for 'regulating the forming and making of Saltpetre', their Secretary being Sir Geo. Wharton. On 16 July a folio Broadside was published to explain the circumstances:

'We having more than ordinary occasion to provide good and sufficient Salt-peter and Powder to furnish Our Stores, for the Defence and Safety of Our Realms and Dominions, have by Commission lately issued under Our Great Seal of England committed the Management thereof to . . . John Lord Berkeley, Sir John Duncombe Knt, Thomas Chicheley Esq., Com-

missioners for the Execution of the Office of Our Ordnance William Legg, Lieutenant of Our Ordnance, John Evelyn Esq., Edward Sherborn Esq., Clerk of Our Ordnance and Jonas Moor Esq., of whose care and fidelities we are well assured: Giving them power by their Deputies and Workmen, to work all Salt-peter and Gun-powder to be made of Saltpeter digged within Our Realm and Dominions and between the hours of Sun-rising and Sun-setting to search for and dig Salt-peter in all convenient places, as well in Our own as Subjects' Lands; but not in any part of Dwelling-houses inhabited, or to break down Walls, or hazard Foundations, or dig in any Threshing or Malting-places without consent of the Owners, nor in Dove-houses, Stables, or other Out-houses, but at convenient times of the day. . . .'

In many the belief in the philosopher's stone continued strong.

William Oughtred (1574–1660) of King's, the mathematician, was a great lover of chymistry, the study of which he continued to an advanced age. He told John Evelyn, R.S.S., 'not above a year before he dyed, that if he were but 5 yeares younger, he doubted not to find out the philosopher's stone. He used to talk much of the mayden-earth, for the philosopher's stone. It was made of the harshest cleare water that he could gett, which he lett stand to petrify, and evaporated by simmering. Ben (his son) tended his furnaces. He told me that his father would sometimes say that he could make the stone. Quicksilver refined and strained, and gold as it came naturall over. . . .' (Aubrey's *Lives.*)

At various times in his career Newton too dabbled in Chemistry. Firstly, as a schoolboy, when he was boarded out with Mr. Clark, the apothecary at Grantham; later on, when in London in August and September 1668 after his election to a Major Fellowship at Trinity, he procured materials for chemical experiments and bought a *Theatrum chemicum* in April 1669.

His kinsman and assistant Humphrey Newton records that when at Trinity between 1683 and 1689, especially at spring and fall of the leaf, he would do with very little sleep, but 'used to employ about six weeks in his elabora-

tory, the fire scarce going out either night or day, he sitting up one night, and I another, till he had finished his chemical experiments'.

Again about 1690–3, he studied Boyle's method for making gold out of mercury, and annotated many of the books in his library with chemical notes. Finally, a great opportunity came to him when, as Warden of the Mint, he carried out the transmutation of England's debased silver into coins of full value. By 1699 the great work was done. He certainly believed that transmutation of metals occurred naturally in mines.

About the year 1683 a really skilled operative chemist, John Francis Vigani, began to teach the subject at Cambridge, whether just before, or just after, the opening of the public Chemical Laboratory in the Old Ashmolean at Oxford is immaterial. It suffices to note that a need was felt in the two Universities at the same time. Cambridge started less well equipped, for whereas Professor Plot at Oxford had a University Laboratory, lecture-room, and operator at his service, Vigani had to make shift with humble quarters in Queens' College.

The scanty materials for Vigani's life have recently been collected by Mr. Saville Peck for the Cambridge Antiquarian Society. He was probably born not later than 1650 at Verona. He tells us that in 1671 he was in Parma, because he saw a quack swallow snake-poison there. Of his education we know nothing, save that he travelled in Spain, France, and Holland, finally reaching England. Doubtless during these years as a wandering scholar he studied mining, metallurgy, and pharmacy, and collected material for his book, *Medulla Chymiae,* the first edition of which was printed at Dantzig in 1682.

Abraham de la Pryme, of St. John's College, was one of his students, and had evidently got bitten, for he entered in his diary under date '1694 Febr. 14. This day I received twelve little retorts and three receivers from London, to try and invent experiments; and all the things that I shall do I intend to put down in a proper book, and in imitation of the most learned Democritus, to give them the title of *χειρόκμητα,* as he did his, which being interpreted implys the Experiments of my own Personal Trying.

'The retorts cost me 4^{d} a piece at London, and the receivers 6^{d}, and I pay'd for their carriage from thence 1^{s} 6^{d}.'[1] During a part of this time Vigani was lodging in Catharine Hall; and so meritoriously did he devote himself to his duties that on 10 February 1703 he was invested with the title of Honorary Professor of Chemistry, which he held until his death in 1713.

Bentley, who three years previously had succeeded to the Mastership of Trinity, being desirous to serve 'the purposes of science and promote the dignity of the College' had 'an elegant Chemical Laboratory' made out of a ruinous Lumber-Hole on the bowling-green of the College. There Cambridge's first Professor of Chemistry was to give lectures illustrated with experiments. He did not, however, find all the conveniences there that he needed at first, and so continued for a time in his old laboratory where William Stukeley,[2] who came up to Corpus as a freshman in November 1703, found him. 'I went to Chymical Lectures with Seignor Vigani at his Laboratory in Queens' College. I took down all his Readings in Writing, and have them in a Book with Drawings of his manner of building Furnaces of Dry Bricks without Iron or Mortar, & his manner of regulating the Fire to any degree of heat.' (Stukeley, *Diary*.)

Fortunately another medical student, John Yardley of Trinity, M.B. 1704, who practised medicine at Cambridge, and died there 1713, also took down Vigani's course. (Caius MS. No. 460, pp. 215.) Whence, the Syllabus

Book i. General Praecognita, Rules for Distillations, Cohobations, Sublimations, Extracts, Tinctures, Chymical Principles, Salts, Colours, Alkali Austera, Crystallization, Fermentation.

Book ii. Of Metals and Minerals.

Book iii. Of Vegetables.

Book iv. Of Animals. Lutes and Fires. Calcination. Extraction. Coagulation.

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[1] *Diary of Abraham de la Pryme*, Surtees Soc. No. 54.

[2] Afterwards the eminent secretary of the Society of Antiquaries 1717–26; M.D. 1719.

That the instruction of Vigani was of the right stimulating kind is proved by Stukeley's enthusiasm—

'At this time (1706) my Tutor [Fawcett] gave me a Room in the College to dissect in, and practise Chymical Experiments, which had a very strange appearance with my furniture in it, the wall . . . hung round with Guts . . . I had Sand furnaces, Calots, Glasses, & all sorts of Chymical Implements . . . I often prepard the Pulvis fulminans & sometime surprizd the whole College with a sudden explosion. I cur'd a lad once of an ague with it by fright. In my own Elaboratory I made large quantitys of Sal volatile oleosum, Tinctura metallorum, Elixir proprietatis, & such matters as would serve to put into our drink.'

In these experiments he was helped by his inseparable friend, STEPHEN HALES, then a newly elected Fellow of the College.

'They applied themselves also to Chymistry and repeated many of Mr. Boyle's experiments, making flowers of Benzoin, Pulvis fulminans, Elixir proprietatis and various preparations, some of use, others of curiosity: but besides what they did between them, they attended the chymical lectures that were then read by the public Professor Signior Vigani in Queens' College Cloysters, and went also to see the chymical operations which he performed in a room at Trinity College which had been the laboratory of Sir Isaac Newton, and in which, unfortunately for the world, Sir Isaac Newton's manuscript concerning chymical principles was accidentally burned.'[1]

Hales must have been a most stimulating pupil. Gilbert White, writing to a friend, quotes the following homely instances of his inventive mind:

'His attention to the insides of ladies' tea-kettles to observe how far they were encrusted with stone that from thence he might judge of the salubrity of the water in their wells:—his advising water to be showered down suspicious wells from the nozzle of a garden watering-pot in order to discharge damps before men ventured to descend;—his directing air-holes to be left in the out-walls of ground rooms, to prevent the rotting of floors and joists;—his earnest dissuasive to young people,

[1] Peter Collinson, *Gentleman's Magazine* 1764, 273; *Annual Register* 1764, Characters 42.

not to drink their tea scalding hot;—his advice to watermen at a ferry, how they might best preserve and keep sound the bottoms or floors of their boats;—his teaching the housewife to place an inverted tea-cup at the bottom of her pies and tarts to prevent the syrop from boiling over, and to preserve the juice;—are a few among many of those benevolent and useful pursuits on which his mind was constantly bent.'

J. E. Harting, *White's Natural History of Selborne*, 1876.

Hales's figure of his apparatus for collecting gases in a receiver distinct from the generating vessel is reproduced on page 238.

Although in no sense a great chemist, Vigani was generally spoken of with respect, and in spite of his being a foreigner he was a successful teacher. Unlike the alchemists, he took experiment for his guide in his researches.

He showed up the error of the alchemists who affirmed that the antimony used to prepare 'emetic wine' or *vinum antimonialis* did not lose weight, for the emetic quality is due to a combination of a portion of the antimony with the tartar in the wine. Vigani also exposed the error of those who regarded pills of metallic antimony and antimony cups (*pocula perpetua*)—in which wine was allowed to stand before being drunk—as 'everlasting'. A duodecimo volume of notes taken at one of his lectures, entitled *Cours de Chemie*—Joan Francis Vigani, is preserved in the University Library.

To illustrate his lectures in 1703 and 1704 Queens' College purchased a representative collection of Materia Medica from Hen. Colchester, druggist at the Maiden's Head in Cheapside; a number of Glasses from Cha. Clutterbuck of Ye Hour Glass in Newgate Street; and a Cabinet of oak of John Austin for £10. The Materia Medica bills, paid by Mr. Poley Clopton, fellow of Queens' and Proctor, came to £51 7*s*. 4½*d*. See p. 330.

Towards the end of his life Vigani left Cambridge and resided at Newark where he had a laboratory, the contents of which were valued at £20 for probate.

About 1708, when Stephen Hales was at Corpus Christi College, the Rev. JOHN WALLER, B.D., the Humanity Lecturer, was making a special study of Chemistry, and

with such renown that later on he was chosen to succeed Vigani in the Professorship, which he held from 1713 to 1717. A set of MS. Notes entitled *Mr. Waller's first Course of Chymistry; upon Vegetables, Animals and Minerals* was included in a volume of lecture notes from the Library of Lord Bateman, recently advertised in a bookseller's catalogue for £30.

In turning to Waller's *Chymistry* (p. 209) we read an observation of local interest, 'Vitriol is a Salt made in Kent of a Stone found by the sea and is much like what we call horse-gold.'

In 1718 Waller was succeeded by the 3rd Chemical Professor, John Mickleburgh, also of Corpus, who continued until 1741. A copy of his notes may be consulted in the library of Caius College. In 1728 a guinea apiece to attend Mickleburgh's course was paid by twenty-three persons, including

Theodore Colladon, Genevensis, doubtless a kinsman of Dr. John Colladon of King's who became naturalized in 1662, and was knighted two years later. A Cambridge apothecary.

In 1735 fourteen persons came to the fourth course, the list commencing with

Charles Mason, A.M., of Trinity, who had become Woodward Professor of Geology in the previous year.

Shepherd Frere (1712–80), Trinity. See page 470.

Mickleburgh's Lectures embraced an encomium on Dr. Freind, who first applied the Newtonian philosophy to Chemistry. Included in his syllabus were disquisitions upon the following:—Calcinations. Distillation of Hartshorn. Analysis of Plants distilled in the Great Alembic. Distillation of Vitriol. Tinctures of Myrrh, Aloes, Saffron, Laudanum, Steel and Antimony, and many by Digestion. Acids and Alkalies. Experiments of Phosphorus. A short course on the Four Elements.[1]

It is miraculous that contemporary professorial science should have flourished as well as it did, for when on 25 March 1736 the University petitioned against a bill to restrain the disposition of lands, it was pointed out that

[1] Wordsworth, p. 189.

the Professor of Chymistry, like his Botanical and Anatomical colleagues, had no endowment at all.

In Cambridge, as elsewhere, the early teaching of Chemistry was very much in the hands of those Professors and Tutors who taught the Medical students; the Professor of Anatomy frequently functioning as Reader in Chemistry, or perhaps rather as instructor in the preparation and properties of such chemicals as were used in pharmacy, or which had some beneficial or harmful effect upon man.

Lectures on Materia Medica were delivered by Dr. William Heberden, senior[1] (St. John's), for ten years round about 1741. His printed syllabus enumerates a large number of chemical substances, and recalls a course which had been delivered in Oxford by John Pointer some fifteen years earlier. In both courses a strong feature was made of the exhibition at the lectures of 'a Specimen of each Particular'; and at the end of their time both teachers presented their collections of specimens to the two Colleges of St. John at the two Universities.

But the contemporary arrangements were far from being satisfactory. An intelligent critic of the General State of Education at Cambridge remarked that 'The Arts subservient to Medicine have no appointments to encourage teachers in them. Anatomy, Botany, Chemistry, and Pharmacy have been but occasionally taught; when some person of superior talents has sprung up and has honoured the University by his first display of them there, before his passage into the world.' So wrote Dr. Richard Davies,[2] in his *Epistle to the Rev. Dr. Hales*, in 1759.

The nature of the course of the 4th Professor, John Hadley, is known from a MS. copy of his *Course of Chemical Lectures read 2 yeares in succession*, preserved as R. 1. 50, 51 in Trinity College.

In 1764 Richard Watson (Trin.) was evidently considered to be a person of such superior talent as to qualify him for being appointed to be the 5th Professor. 'He knew nothing at all of Chemistry, had never read a syllable on the subject, nor seen a single experiment in it, at the time this honour was conferred' upon him. But he sent to

[1] Heberden, Fellow of St. John's 1731–52; M.D. 1739; F.R.S. 1750.
[2] F.R.S. 1738; M.D. in practice in Bath.

Paris for an operator, and did so many experiments in his laboratory, that in fourteen months he began to lecture to a very full audience. It must have been at this time that Dr. S. Johnson visited Cambridge and witnessed the fiery reaction of vitriol on turpentine. The two liquids were held out of a window on two sticks.

Watson must have been a real live wire, for by his exertions he so impressed the Crown that in 1766 an endowment of £100 a year was henceforth contributed as a stipend for the Professor of Chemistry, who in due course became an F.R.S. and Bishop of Llandaff.

> There was no stipend annexed to the Professorship of Chemistry, nor any thing furnished to the Professor by the University, except a room to read lectures in. I was told that the Professors of Chemistry in Paris, Vienna, Berlin, Stockholm, &c., were supported by their respective monarchs; and I knew that the reading a course of lectures would every year be attended with a great expense; and being very hearty in the design of recommending chemistry to the attention of the youth of the University and of the country, I thought myself justified in applying to the minister for a stipend from the Crown. Lord Rockingham was then Minister (1766), and Mr. Luther, who had lately spent above twenty thousand pounds in establishing the Whig interest in Essex, undertook to ask for it. Though an hundred a year given for the encouragement of science, is but a drop in the ocean, when compared with the enormous sums lavished on unmerited pensions, lucrative sinecure places, and scandalous jobs, by every Minister on his flatterers and dependants, in order to secure his majorities in Parliament, yet I obtained this drop with difficulty. . . .
>
> The ice being thus broken by me similar stipends have been since procured from the Crown, for the Professors of Anatomy and Botany, and for the recently established Professor of Common Law. The University is now much richer than it was in 1766; and it would become its dignity, I think, to thank the King for his indulgence, and to pay in future its unendowed Professors without having recourse to the public purse.[1]

He delivered courses in November 1766–8. In 1768 he printed *Institutionum chemicarum in praelectionibus*

[1] Cooper, iii, p. 343.

academicis explicatarum pars Metallurgica, designed a series of chemical propositions in Rutherforth's *System,* and sent to the Royal Society a paper entitled *Experiments & Observation on various Phaenomena attending the Solutions of Salts,* for which he was elected a Fellow.

His later works included an *Essay on the Subjects of Chemistry, and their general division,* 1771; a *Plan of a Course of Chemical Lectures,* Camb. 1771; and *Chemical Lectures,* 1781–2, 1786.

His device of distilling wood in close vessels was said to have saved the government £100,000 a year for gunpowder (c. 1787). His electrical experiments are noted on p. 112, and his discovery of the black-bulb thermometer on p. 97.

The most important of Watson's *Chemical Essays,* which appeared in five 16mo volumes in 1784–8, were:

(1) *On the Degrees of Heat at which Water boils.* The experiment described was that of boiling water in a closed flask nearly free from air.

(2) *On Pit-Coal* (1781), suggesting the condensing of the volatile products from coke-ovens, an operation which has still a great industrial future.

(3) *On the smelting of Lead Ore* (1781), suggesting the condensation of lead fumes, and of the sulphurous acid produced when sulphides are roasted.

(4) *On Zinc* (1786).

Various papers published in the *Philosophical Transactions* were also reprinted.

After Watson became Bishop of Llandaff in 1782 his health proved inadequate for his double duties, so he was allowed to appoint a deputy in his professorship, and Dr. Kipling of St. John's undertook the office at a salary of £200 a year. The Bishop built an excellent house on Windermere and improved the vicinity by numerous plantations.

The discovery of the chemical composition of water has been attributed to HENRY CAVENDISH and to James Watt, but in 1851 the former's biographer, Dr. George Wilson,[1] showed that the merits of Watt as a discoverer of the

[1] *Life of Hon. H. Cavendish* by G. Wilson, M.D., 1851.

composition of water had been overestimated by Muirhead and Lord Jeffrey.

The Hon. Henry Cavendish had inherited some interest in science from his father, who was a meteorologist. He was matriculated and admitted a fellow-commoner of Peterhouse in December 1749, but left without taking a degree. He will always be remembered as one of the great pneumatic chemists of the 18th century, for it was by the methods of pneumatic chemistry that he made his great discovery.

His portrait has been placed in one of the windows of Peterhouse hall.

Cavendish had been informed by Waltire, a fellow worker of Priestley's, that when a mixture of hydrogen and air was fired in a vessel, dew appeared on the interior of the vessel. So on repeating the experiment Cavendish proved that Water, instead of being one of the four elementary bodies, was a compound of 'inflammable air' or Hydrogen united with Priestley's 'dephlogisticated air' or Oxygen.

He also found that when the mixture of hydrogen and oxygen was fired by an electric spark, the water formed was acid with nitric acid. This he attributed to a trace of atmospheric nitrogen in the oxygen used, and then showed that oxygen and nitrogen do combine when an electric discharge is passed through them. After absorbing the nitric acid formed he detected a shrinkage of volume when sparks were passed through a mixture of nitrogen and oxygen, but by continuing the process he eventually reached a point at which no further shrinkage occurred, and this was when about 1/120th of the original volume of nitrogen remained. We now know that this remnant must have consisted of the inert gas, Argon, thus unconsciously discovered by Cavendish more than a century before its recognition by Lord Rayleigh in 1894.

When Watson resigned the chair, a grace was passed on 20 November 1773 that *pro hac vice* the election for a Professor of Chemistry should be *secundum morem in Electione Burgensium receptum.* Accordingly on 15 December the voting was between Isaac Pennington, fellow of St. John's, and one of the physicians to Addenbrooke's

Hospital, who was elected with 148 votes, as against the 128 polled by William Hodson, fellow of Trinity. When Pennington added to his duties, which do not appear to have included lecturing, by becoming Regius Professor of Medicine, he appointed I. MILNER of Queens' to lecture as his deputy, and Milner printed a *Plan* of Chemical Lectures in 1784. He was assisted by a German chemist of the name of Hoffman, whom the men called the 'French Doctor'. (Gunning, *Reminiscences*, i, p. 236.)

We have independent evidence that chemistry was being taught about 1785, for when J. B. Seale, the classical lecturer at Christ's, was examining one of his pupils on a lecture on Locke, which he had delivered the day before, he asked him to define 'a mixed mode'. The man applied to jogged his neighbour to give him an opportunity of reading from his notes. He immediately opened his book, which contained notes of a *chemical* lecture, and the pupil delivered the following answer with great apparent satisfaction to himself: 'It is the hardest of all metals, malleable, fusible, and soluble in aqua regia.'

'Coak ovens' were in full working order at Cambridge in 1789 for preparing coke in quantity for the drying of malt. Professor Watson found that 30 bushels of coal yielded 39 bushels of 'cinders', of less weight. The Cambridge ovens were drawn once in 24 hours. In Watson's day coke was coming to be used more and more for extracting iron from its ore instead of wood charcoal, though the product was never as good. A ton of coals yielded 11 cwt. of 'cinder'.

In 1793 W. FARISH (Magd.) succeeded as 7th Professor, and lectured on *The Application of Chemistry to the Arts and Manufactures of Britain.*

After a preliminary survey of almost everything curious in the manufactures, the Professor contrived a mode of exhibiting the operations and processes that are in use in nearly all of them. Having provided himself with a number of *Brass Wheels* of all forms and sizes, such that any two of them can work with each other, the *Cogs* being all equal; and also with a variety of *Axles, Bars, Screws, Clamps,* &c., he constructs at pleasure, with the addition of the peculiar parts, *working Models* of almost every kind of *Machine*. These he puts in motion by a *Water Wheel,* or

PROFESSOR SIR ISAAC PENNINGTON, M.D., F.R.C.P.

By courtesy of the Cambridge University Press

a *Steam Engine,* in such a way as to make them in general do the actual work of the real Machine on a small scale; and he explains at the same time the chemical and philosophical principles on which the various processes of the Arts exhibited depend.

In the course of his lectures he explains the theory and practice of *Mining* and of *Smelting* metallic Ores—of bringing them to nature—of converting, purifying, compounding, and separating the Metals, and the numerous and various Manufactures which depend upon them, as well as the Arts which are more remotely connected with them, such as *Etching* and *Engraving.* He exhibits the method of obtaining *Coal* and other *Minerals,* the processes by which *Sulphur, Alum, common Salt, Acids, Alkalies, Nitre,* and other *saline* substances are obtained, and in which they are used; the mechanical process in the formation of *Gunpowder,* as well as its theory and effects. He shows the arts of procuring and working *Animal* and *Vegetable* substances; the great staple manufactures of the country, in *Wool, Cotton, Linen, Silk*; together with the various chemical arts of *Bleaching,* of *Preparing* Cloth, of *Printing* it, of using *adjective* and *substantive* colours, and *Mordants* or *Intermediates* in Dyeing. He explains in general the nature of Machinery: the moving powers, such as *Water wheels, Windmills,* and particularly the *agency* of Steam, which is the *great* cause of the modern improvement and extension of manufactures. He treats likewise on subjects which relate to the carrying on, or facilitating, the commerce of the country, such as *Inland Navigation,* the construction of *Bridges, Aqueducts, Locks, Inclined Planes,* and other contrivances by which *Vessels* are raised or lowered from one Level to another; of *Ships, Docks, Harbours,* and *Naval Architecture.*

On the whole it is the great design of these Lectures to excite the attention of persons already acquainted with the principles of Mathematics, Philosophy, and Chemistry, to *Real Practice*; and by drawing their minds to the consideration of the most useful inventions of ingenious men, in all parts of the kingdom, to enlarge their sphere of amusement and instruction and to promote the improvement and progress of the Arts.

These Lectures were given in the Schools in the Botanical Garden, alternately with those of the *Jacksonian* Professor, in the *Lent* and *Midsummer Terms.*[1] (Wordsworth.)

Soon after Farish's election a grace passed the Senate that all future elections to the Professorship of Chemistry should be *secundum morem in Electione Burgensium receptum*: 24 Oct. 1794.

It is said that about 1796 Francis J. Hyde Wollaston (Trin. Hall, 1792), the second Jacksonian Professor of Natural and Experimental Philosophy, devoted himself exclusively to Chemistry, thus poaching on the Chemistry Professor's ground. This explanation has been offered for Professor Farish lecturing on Mechanics and Industrial Chemistry, but it may well have been the other way round.

Twelve students were permitted to attend Wollaston's lectures *gratis*, four being of Trinity College.

Nineteenth Century

Smithson Tennant (1761–1815) succeeded Farish in 1813, but died in 1815 owing to the fall of a drawbridge near Boulogne. He had been one of Joseph Black's students at Edinburgh and came up to Christ's in 1782. Chemistry was a passion with him, frequently causing him to neglect his meals. When at a loss for a piece of linen to filter some of his preparations, he never scrupled taking a part of a cambric handkerchief for the purpose, or cutting a piece off a shirt. At Cambridge he continued his chemical studies and became convinced of the truth of the antiphlogistic theory. In 1790 he removed to Emmanuel, and later, after some years of continental travel, to London. At his chambers in the Temple he delivered a course of informal lectures on mineralogy in 1812, the merits of which were recognized by his appointment to the Cambridge chair of chemistry in the following year.

In his first paper he published the evidence for the composition of 'fixed air' (CO_2) by an analytical method, depending on his discovery that when marble is heated

[1] *Univ. Calendar* 1802, pp. 24, 25; *Facetiae Cantab.* 1836, p. 154; *Edinb. Review* of 1st No. of *Cambridge Phil. Trans.* in 1821. (Wordsworth.)

with phosphorus, carbon is liberated. *Phil. Trans.* 1791. He is also remembered for showing that the diamond is the purest form of carbon, in an article *On the Nature of the Diamond, Phil. Trans.* 1797. In 1799 he discovered that lime from many parts of England contains magnesia and that this substance and its carbonate are injurious to vegetation.

Osmium and Iridium were discovered by him in 1804 in the undissolved residues when crude platinum is acted on by aqua regia. For this he was awarded the Copley Medal. His other papers were:

'*On the action of Nitre on Gold and Platina*', *Phil. Trans.* 1797.
'*On the composition of Emery*', *Phil. Trans.* 1802.
'*Notice respecting native concrete Boracic Acid*', *Trans. Geol. Soc.* 1811.
'*On an easier mode of procuring Potassium*', *Phil. Trans.* 1814.
'*On the means of procuring a Double Distillation by the same heat*', *Phil. Trans.* 1814.

It is generally accepted that after the 17th century it became increasingly difficult for any one man to excel in all branches of science simultaneously, but William Hyde Wollaston (1766–1828) of Caius 1782–†1828, M.D. 1793, certainly did so. During the thirty years after his 31st birthday, when he read his first medical paper on *Calculi*, he published 56 papers on 'pathology, physiology, chemistry, optics, mineralogy, crystallography, astronomy, electricity, mechanics, and botany', and his biographers state that almost every paper marks a distinct advance in the particular science concerned. Truly a very great achievement when we remember that he was handicapped by partial blindness in both eyes, the result of overstrain of vision which had been more than ordinarily acute.

After retiring from medical practice in 1800 he set up a laboratory at the back of 14 Buckingham Street, Fitzroy Square, which he guarded with all the jealousy of an alchemist on a gold quest. There, in five years of work while perfecting a process for making platinum malleable, he discovered Palladium, samples of which he exposed for sale at the shop of a Mrs. Forster, 26 Gerrard Street, Soho.

A copy of the original leaflet advertising its properties and price is exhibited in the Mineralogical Museum at Cambridge. Thereupon ensued one of the comedies of chemistry. R. Chenevix bought up the stock, and read a paper before the Royal Society to show that palladium was an imposture—a mere alloy of platinum with mercury. Wollaston thereupon discovered a second platinum metal, Rhodium, and by obtaining pure platinum 'destroyed the chemical reputation of Chenevix', who abandoned the science of chemistry. Later he discovered the identity of Columbium and Tantalum, and recognized the existence of Titanium in the slags of blast furnaces.

247 Iron Press for Compressing Platinum. 1829.

Cavendish Laboratory.

Made for and used by W. H. Wollaston. *Phil. Trans.* 1829.

Length 4 ft. 3 in. Powdered platinum was confined in cylinders of about 6 inches in length, and compressed by the action of a long lever. See figure on p. 72.

The Palladium Leaflet. 1802.

Dept. of Mineralogy.

W. H. Wollaston's discovery of Palladium or 'New Silver' was advertised by a leaflet setting forth its properties and price.

After a clear explanation of Dalton's Atomic Theory had been given in Thomson's *System of Chemistry* for 1807, Wollaston not only accepted it, but tried to convert Sir Humphry Davy to it, though without success. His work on the two kinds of oxalates and on 'Super-acid and Sub-acid salts' further consolidated the position and convinced him that 'a geometrical conception' of atomic arrangements in three dimensions was necessary. This suggestion has now been adopted in the science of Stereo-chemistry.

In 1814 he published a *Synoptic Scale of* [Chemical] *Equivalents* and for the aid of analysts he contrived a Slide Rule for assisting in the calculations of the results of quantitative analyses. Some of his experimental slide-rules are still in the Cavendish Laboratory, see p. 53.

PALLADIUM;

OR,

NEW SILVER,

Has these Properties amongst others that shew it to be

A NEW NOBLE METAL.

1. It dissolves in pure Spirit of Nitre, and makes a dark red solution.

2. Green Vitriol throws it down in the state of a regulus from this solution, as it always does Gold from *Aqua Regia.*

3. If you evaporate the solution you get a red calx that dissolves in Spirit of Salt or other acids.

4. It is thrown down by quicksilver and by all the metals but Gold, Platina, and Silver.

5. Its Specific Gravity by hammering was only 11.3, but by flatting as much as 11.8.

6. In a common fire the face of it tarnishes a little and turns blue, but comes bright again, like other noble metals on being stronger heated.

7. The greatest heat of a blacksmith's fire would hardly melt it;

8. But if you touch it while hot with a small bit of Sulphur it runs as easily as Zinc.

IT IS SOLD ONLY BY

MR. FORSTER, at No. 26, GERRARD STREET, SOHO, *LONDON.*

In Samples of Five Shillings, Half a Guinea, & One Guinea each.

J. Moore, Printer, Drury Lane

With Smithson Tennant he discovered that explosion in mixtures of gases will not pass through small tubes, a fact utilized by Davy in his first Safety Lamps. (*Phil. Trans.* 1816.) His *Chemical Course* was printed at Cambridge in 1794.

The published works of the 9th Professor, James Cumming, show that his interests were electrical, rather than chemical. See p. 115.

To the Professor of Mineralogy, the Rev. Edward Daniel Clarke, chemists are indebted for a most useful aid, the Oxyhydrogen Blow-pipe. *The Gas-Blow pipe or Art of Fusion by burning the gaseous Constituents of Water: giving its History, the proofs of Analogy in its Operations to the Nature of Volcanoes, and Appendix of Experiments.* With a frontispiece of the Apparatus. 1819. It was made by John Newman of Lisle Street, and described by him in 1817, with analyses of 96 minerals.

In 1819 John George Children, F.R.S., of the British Museum, published an '*Essay on Chemical Analysis*, chiefly translated from Thénard's *Traité de Chimie*, Vol. iv. 1819,' and with [Sir] J. Herschel of St. John's contributed a notable paper on Hypo-sulphurous acid.

In 1823 the town was lit with gas; by Oil gas at first, but a few years later Coal gas was substituted. And on 22 May 1834 royal assent was given to an Act to incorporate a Company for better supplying with Gas the Town of Cambridge.

It was a period when the public took a great deal of interest in chemistry, as is recalled by an article entitled *Practical Helps to a Cheap Course of Self-Instruction in Experimental Chemistry*, contained in the *Mechanics Magazine* for 12 April 1834:

'The extensive utility of chemical knowledge has caused it to be very generally, nay, almost universally cultivated; but it is a branch of philosophy so entirely founded on experiment, that no person can understand it so as to verify its fundamental truths, unless he conducts experiments himself. . . . A notion that a laboratory, fitted up with furnaces and expensive and complicated apparatus, is absolutely necessary to perform chemical experiments is exceedingly erroneous; in fact diametrically opposite to the truth. For all ordinary chemical

purposes and even for the prosecution of new and important inquiries very simple means are sufficient.'

The writer gave a list of pieces of apparatus and of the substances which should be obtained, the whole of which were considered to be within the reach of persons even of the most modest means, and intending experimenters were advised to purchase their chemicals from either Mr. Dymond, 146 Holborn-bars, or Mr. Davy, 390 Strand. (*Nature* 1934.)

There were great complaints in 1828 because the Professor had no room in which to lecture.

Duncan Farquharson Gregory (Trinity, B.A. 1836), great-great-grandson to James Gregory (1638–75), acted for a time as assistant to the Professor of Chemistry, but ultimately specialized on mathematics and founded the *Cambridge Mathematical Journal.*

Photography

The art of the photographer may be said to have commenced with Scheele's discovery that light blackened chloride of silver. Two Cambridge men contributed to further advance. W. Hyde Wollaston observed an analogous change in the yellow gum guaiacum. In 1802 Thomas Wedgwood (1771–1805) obtained the first evanescent photographic prints by throwing shadows on paper moistened with nitrate of silver, but there was then no known method of fixing the effect.

This fundamental discovery was made in January or February 1839 when Sir John Herschel found out that hyposulphite of soda would dissolve otherwise insoluble silver salts. It was a discovery which revolutionized photography. The entry in his laboratory note-book runs as follows:

1839. Jan. No. 1013. 'Tried hyposulphite of soda to arrest the action of light, by washing away all the chloride of silver or other silvery salt. Succeeds perfectly. Papers $\frac{1}{2}$ acted on $\frac{1}{2}$ guarded from light by covering with pasteboard were when withdrawn from sunshine, sponged over with hyposulphite of soda, then well washed in pure water, dried and again exposed. The darkened half remained

dark, the white half white after any exposure as if they had been painted with sepia.'

In the same year Herschel wishing to ascertain more fully how far organic matter is indispensable to the decomposition of the salts of silver by light, used glass plates to receive, under water, a deposit of 'muriate' (chloride) of silver from a mixed solution of the nitrate with common salt. His MS. record of this crucial experiment in photography goes on to say: 'After 48 hours (the chloride) had formed a film firm enough to bear draining the water off very slowly by a siphon. Having dried it I found that it was very little affected by light; but by washing with nitrate of silver, weak, and drying it, it became highly sensible. In this state I took a camera picture of the telescope on it.' He exposed it 'with the glass towards the incident light', and fixed the image with hyposulphite of soda, the solvent action of which on chloride of silver he had announced 20 years earlier. The 'negatives' as he called them, thus taken, were the first obtained on glass, and from them he printed a few positives, now lost. The negative of this is exhibited in the South Kensington Museum, and now after more than half a century, 25 copies have been printed from it by projection, true to it in size. *Phil. Trans.* 1840. (W. J. Herschel, Aug. 1890.)

In the Report of the Royal Commission of 1852 it was stated that the stipend of the Professor of Chemistry was £241 16*s*. 11*d*., of which Parliament voted £96 16*s*. 11*d*.

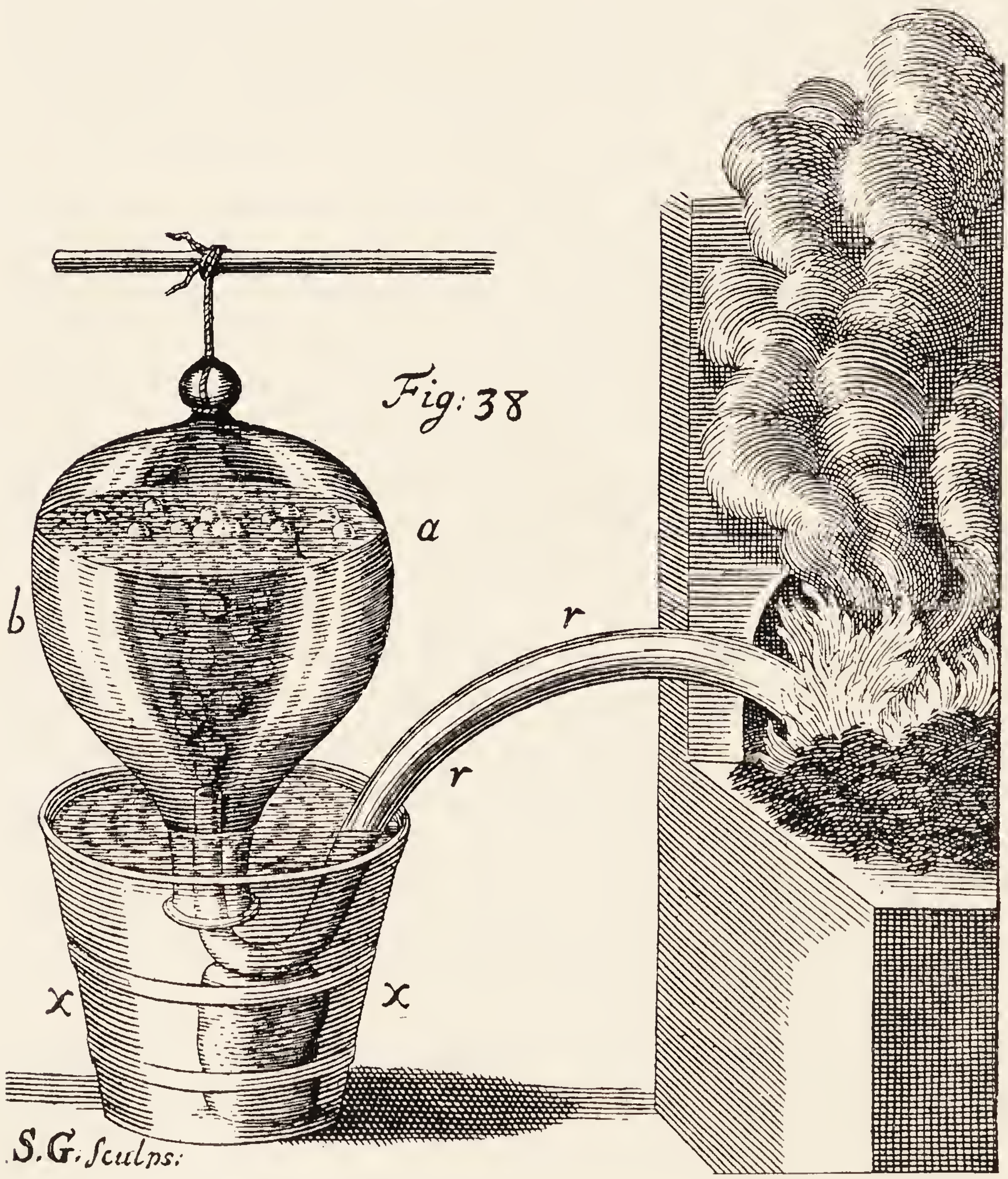
In 1861 George D. Liveing (St. John's) was appointed 10th Professor, and one of his first pupils in chemical analysis was John William Strutt, who resented the narrowness of the courses in experimental science—only chemistry, mineralogy, and biology being open to him. 'It wasted three or four years of my life.' However, 33 years later he discovered 'Argon, a new Constituent of the Atmosphere'. As late as 1872 all students, whether beginners or more advanced, had to work in a single room.

248. Early Photographs taken by Sir John Herschel fixed by him in 1839.

Dr. R. T. Gunther.

PROFESSORSHIP OF CHEMISTRY. 1702

1. JOHN FRANCIS VIGANI of Verona. 10 Feb., 1702/3.
2. J. WALLER, Corpus, 1713.
3. J. MICKLEBURGH, C.C.C., 1718.
4. JOHN HADLEY, Queens', 1756.
5. RICHARD WATSON, Trinity, 1764.
6. ISAAC PENNINGTON, 1773.
7. W. FARISH, Magdalen, 1793.
8. SMITHSON TENNANT, 1813.
9. JAMES CUMMING, Trinity, 1815.
10. GEORGE D. LIVEING, St. John's, 1861.
11. Sir WILLIAM JACKSON POPE, Peter's and Sidney, 1908.



HALES'S APPARATUS FOR COLLECTING GASES.

IX

MEDICINE

While the following pages were being prepared for the press, a third skull of the Bronze Age period has been found showing that the owner had been trephined, presumably with a flint instrument, and had recovered from the operation. This skull is now in the Brighton Museum, and proves that it is not impossible that the operation of opening the brain may also have been practised in East Anglia as early as 500 B.C.

Evidences for the practice of Medicine in Cambridge and its vicinity in very early times are of the scantiest, yet there are good grounds for believing that, as at Oxford, infirmaries for the sick and leper-houses were founded there in the reign of Henry I. Crusaders returning with grateful experiences of Syrian rest-houses, and desiring to provide their own countrymen with similar conveniences piously founded institutions like St. Bartholomew's Hospital, which dates from 1123.

Statutes defining the conditions of admission to these homes varied greatly. Patients who might be suffering from leprosy, paralysis, dropsy, pregnancy, or other incurable diseases might, as often as not, find themselves automatically excluded. But one undoubted leper-house was the hospital of St. Mary Magdalen at Sturbridge, to which, by way of endowment, the celebrated fair was granted by King John in 1211.

According to Lysons there were three ancient hospitals in Cambridge. The first of these, the Hospital of St. John, was founded in the 12th century by Henry Frost, burgess of Cambridge, for a master and brethren, but was

suppressed in 1509 for the purpose of founding St. John's College. The second, the Hospital of St. Anthony and St. Eligius for lepers was existing in the 14th century. The third, the Hospital of Lazarus was founded by Henry Tangmer.

The Leper-house of St. Mary Magdalen at Sturbridge was at first in the patronage of the burgesses of Cambridge, but in the reign of Edward I it is stated to have been unjustly seized by the Bishop of Ely, who had cast out the lepers who ought, and used to be there supported, and had placed chaplains in their place. Leprosy must have been more common then than now, but may not have been more contagious. The modern view on this point was dramatically expressed by Dr. Le Mu of Tahiti, 'I would rather shake hands with a hundred lepers than face the germs contained in one sneeze.'

In Chatteris, at Hunny farm, was a chapel in which the bones of St. Huna, chaplain to St. Etheldreda, foundress of Ely (†679), effected 'wonderful cures' before they were translated to Thorney.

It was not unusual for persons in need of medical treatment to resort to the great religious houses, where the reputation of one or more of the brethren for his skill in simple chirurgery, or for his cunning in the use of herbs, may have spread beyond the convent walls. It is known that at Bury St. Edmunds the monks had a copy of the *Herbal* of Apuleius Barbarus, which has been recently produced in facsimile by the Roxburgh Club.

A treatment that was in great favour in medieval convents in the thirteenth century and indeed was scarcely less methodically practised than the weekly fast on Fridays, was the good old Galenic remedy of letting blood. And at Ely, at all events, they had a special Blood-letting House, with space to accommodate one-sixth of the total number of monks, say six to ten brethren. On a definite day in the year the Prior with a group of monks under his charge would repair to the appointed spot and be bled. After the operation they would remain to recruit their strength and to enjoy the relaxations of the house for three days. A week later it was the turn of the Cellarer and his set to be bled, and they stayed three days. And so on at intervals of

a week the Sacrist, Precentor, Chamberlain, and Sub-prior, each with his set. Then, after a month and a half, it would be the turn of the Prior's party again; so that each monk was bled about eight times in the year at intervals of six weeks. The three days' indulgence received an important extension in 1287, when patients received permission to spend the third day and night outside the monastery.[1]

Only a few of the early physicians are now remembered by name, but among them NIGEL THORNDON must have been able to acquire property, for in 1347 he gave houses in Cordiner's-row for the support of the chaplain whose duty it was to recite the names of the benefactors to the University.

And about the same time occurred an event of the first importance, when the King empowered EDMUND GONVILLE to convert his property into a perpetual college of twenty scholars, students in logic and other sciences. Two centuries later this foundation of Gonville Hall was refounded by John Caius and became a most prolific nursing mother for generations of medical men.

The advance of medical knowedge has been fostered less by any desire for the advance of scientific learning for its own sake, or by intensive study of great volumes of manuscript copies of ancient medical writings, than by those occasional onslaughts of epidemic pestilence which by faulty treatment often led to the decease of the physician as well as of the patient. In the course of time, by a process of natural selection, the man of real knowledge survived, while the quack and the charlatan was eliminated, finding perhaps a common grave with his dupes.

The Black Death

The most serious of these epoch-making epidemics was the Black Death of 1348.

The predominating symptoms were an ardent fever, causing a thirst that no beverage would assuage, accompanied by an evacuation of blood; the lungs were seized with a putrid inflammation. Later, buboes in the axilla and in the groin appeared. Death followed within three days and the disease was proved to be contagious.

[1] Atkinson, *Monastic buildings of Ely.*

In England it began in Dorset, whence it advanced through Devon and Somerset to Bristol. Thence it reached Gloucester, Oxford, and London. In Norwich alone 51,100 deaths were reported.

The cause was believed by Guy de Chauliac to have been the grand conjunction of the three superior planets Saturn, Jupiter, and Mars in the sign of Aquarius on 24 March 1345. And the medical faculty of Paris drew up a report stating 'We are of opinion that the constellations with the aid of Nature, strive by virtue of their divine might to protect and heal the human race'.

So also, in 1389, it is recorded that Cambridge suffered

> a sad mortality in the town and University, proceeding from the infection of the air, and that caused from the unclean keeping of the streets. Now such was the malignity of this disease, that presently it infected the brain, so that instantly men ran raving mad, and which was strange, starved themselves to death . . . the distemper continuing for many weeks together.

The immediate result of such a visitation was the engendering of quacks and quack-remedies, of practitioners who had not had any long and difficult course of medical study, of nostrums whose efficacy for good was often less potent than for harm. So great became the abuses that the medical faculty was compelled to take action. In self-defence a petition was presented on 2 May 1421 in parliament with the object of restraining those who had not graduated in the Faculty of Medicine from practising that art. It recited that

> for so moche as a man hath thre things to govern that is to say Soule, Body, and wordly Goudes, the whiche ought and shulde ben principaly reveled by thre Sciences, that ben Divinite, Fisyk, and Lawe, . . . But as hit is knowen . . . many unconnyng and unapproved in the forsayd Science practiseth, and specialy in Fisyk, so that in this Roialme is every man, be he never so lewed, takyng upon hym practyse, y suffered to use hit, to grete harme and slaughtre of many men: Where if no man practised thereyn but al only connynge men and approved sufficeantly y lerned in art, filosofye, and fisyk, as it is kept in other londes and roialms, ther shulde many man that dyeth, for defaute of

help, lyve, and no man perysh by unconnyng. Wherefore pleseth to youre excellent Wysdomes . . . to ordeine and make in Statuit, . . . that no man of no manner estate, dyre or condicion, practyse in Fisyk, from this tyme forward, but he have long tyme y used the Scoles of Fisyk withynne som Universitee, and be graduated in the same; that is to say, but he be Bachelor, or Doctour of Fisyk, havynge Letters testimonyalx, sufficieantz of on of those degrees of the Universite in the whiche he toke his degree yn; undur peyne of long emprisonement, and paynge XL li to the Kyng; and that no Woman use the practyse of Fisyk undre the same payne. . . . (*Rotuli Parliamentorum*, iv. 158.)

The continuance of pestilential conditions was attributed, and rightly attributed, to the general neglect of ordinary sanitation in the town. In 1447 Henry VI wrote: 'Nevertheless for the aier and ye Pestilence that hath long regned in our said Universitee we come not there at this time, but send thiddre our Cousin the Marquesse of Suffolk . . .' Ultimately the continuing heavy death-roll and the action of the king caused steps to be taken in the right direction, and in 1459 it was ordered that garbage, carcasses, and other filth were not to be cast into ditches, rivers, waters, &c., and that the Chancellor was to amerce the offenders.

The earliest Cambridge physician who is known to have attained to fame and fortune was WALTER LEMSTER (? 1440–87) of King's. In 1477 he was appointed medical attendant to the Bishop of Ely, who not only settled a pension of 20 marks for life but decreed that he should have bed, board, and travelling expenses for two servants and three horses whenever he should make the journey from Cambridge to Downham where the sick bishop dwelt. For the last three years of his life Lemster also enjoyed a pension of £40 from King Henry. In 1470, when still living at Cambridge, he attended his daughter-in-law Lucy 'in tyme of hir sore and gret sekenes' and helped her in a breach of promise action against Richard Narborough, D.C.L., of Cambridge.

A prominent physician of the time was JOHN ARGENTINE (Eton and King's College), M.D., Proctor 1472, who became Physician to Arthur, Prince of Wales. Verses by

him on geometry, astronomy, and medicine, &c., are preserved in a MS. in C.C.C., Oxon. He died in 1507–8.

Another fell disease, the Sweating Sickness, is believed to have broken out among the soldiers of Henry VII's army in 1485. It reappeared in London in 1506, again in London and in Cambridge in 1517, and again in 1528–9 and 1551. On the last occasion it was monographed by John Caius (p. 248).

At the beginning of the 16th century the University enacted that even the humbler members of the profession should be under control, and at the same time 'All appotycares . . . physitions, surgeons and barbers in the Universitie practising within it shall have the same privilege as a Scolers Servant in the University' (1503). *Endorsed* 'Bowen, Surgeon'.

This was followed in 1511 by the first Medical Act concerning country doctors, who were everywhere put in the hands of the Bishop, who as often as not relied for their expert knowledge on the testimony of honest men.

The position and training of physicians at the Universities now became profoundly influenced by the precept and example of the most erudite master of medicine of his age, THOMAS LINACRE, court physician to the King in 1509. And it may well have been by his counsel that the dignity of the holders of the higher degrees was enhanced by that Act of Parliament of 1532–3 which permitted Doctors 'to weare sarcenett in the lynyng of their gownes, blacke sateen, or black chamlett in their doublettes, and furres called gray, black boge, foynes shankes or menever'.

Among the other distinguished doctors of the time were—

WILLIAM BUTTS, pensioner of Gonville Hall 1506, M.D. 1518, whose portrait by Holbein figures in the picture of the delivery of the charter to the barber-surgeons, and has been engraved. He was a friend of Wolsey, Latimer, and Cranmer, and a good courtier.

At the assize kept at the Castle in Lent 1522 'the Justices and all the gentlemen, Bailiffs, and other resorting thither, tooke such an infection that many gentlemen and yeomen thereof dyed, and almost all which were there present were sore sicke and narrowly escaped with their lives'. *Hale's Chronicle* quoted by Coghan, who diagnosed the

disease as *Febris ardens*, a burning fever, of the kind with which the Lord punished his people (cf. Leviticus and Deuteronomy). T.C. *Haven of Health*, 1584.

Thomas Gibson was educated at Oxford, but one of his name took an M.D. at Cambridge in 1511. He was licensed in 1559 and died in London in 1562. He was very skilful in curing diseases, and is believed to have written:

1. *A treatise behoovefull as well to preserve the people from pestilence, as to help and recover them that be inflicted by the same, made by a bishop and Dr. of physic in Denmark, which medicines have been proved in many places in London.* 1536.
2. *The great Herball newly corrected.* Lond. 1539.
3. *Treatise against unskilful Alchimists.*
4. *Treatise of curing common diseases.*

John Thomas (? 1490–1545) was licensed to practise surgery in 1514 and continued to do so for thirty years. From a most detailed inventory of his goods at his death Dr. W. Palmer has reconstructed a telling picture of the habits and surroundings of a Cambridge surgeon living before the Reformation.

He lived in a three-storey house of eight rooms, one of which was a surgeon's shop. The shop window was fitted with a frame of canvas, perhaps put up when some operation had to be screened from prying eyes. He had one latten and two brass mortars, a little melting pan, a pile of Troy weights, a hair sieve, a chaffer with a lid, and two things of pewter to box salve with. In addition to 6*s*. 8*d*. worth of 'bottles, pots, salves, boxes and other trash', he left 2*d*. worth of alegar, or sour beer, a pot of may butter, small quantities of alum, wax, and rosin, a sheepskin for plasters, four pounds of flare for ointments; 14 lb. of iron to make steel wine, valued at 4*d*. per lb. His surgical outfit included 5 little tools for teeth 2*d*., ten old tools 6*d*., a leather bag with tools and boxes 12*d*. His principal medical books were the works of Guido de Chauliac and John de Vigo in French or Latin, and of course Galen, the *Rule of Salerno*, and George Valla. No volume was valued at more than 8*d*.

The Salernitan regime is clearly indicated in *Baker MS.*

32. 25, where the Earl of Oxford 'shall avoid hot wines or meats, late hours, excessive hunting, wild companions, superfluous apparel'. 16 Feb. 15 Hen. VIII.

The education of the Barber-surgeon did not need to be very profound. He had to learn the twenty points on the body where blood could be drawn from veins, to learn the proper vein for each disease, and the proper hour of the day when phlebotomy should be performed, according to the accepted Table of the signs of the Zodiac.

His instruments were often limited to a single set of lancets in a case. And the wills of three Cambridge surgeons of the 16th century do not disclose much else of operative value.

In 1552 John Soward of Clare had a box with 4 silver instruments worth 4*s.*, a syringe with a pipe of silver, a pair of scissors, and other instruments.

Richard Willows of Bridge Street left 'All his instruments, 4 cupping glasses, one payer of scales and other trash—5*s.*'

John Paske, surgeon, had no instruments worth recording other than a grindstone, three axes, 2 hatchets, eleven wedges, and a 'wrong' hook.

In the next century Edward Allot, professor of surgery, died in 1636 leaving a silver box of instruments valued at £15. Contemporary apothecaries stocked silver catheters as well.

One of Clement hostel, called Sir Henry the conjurer, on account of his skill in the black art, falling sick of the plague was visited by George Stafford (Fellow of Pembroke Hall) who argued on his wicked life and practices, brought him to repentance, and caused all his conjuring books to be burnt before his face: but Stafford caught the infection and died between 19 June and 17 Nov. 1529. He was a reader in Divinity and not licensed to practise medicine.

Robert Pickering, M.D., died in 1551, the year of the great sweat. He was a practising physician of St. Mary's Parish, and attached to his house was a shop which was better furnished than the surgery of Mr. Thomas. There were two fair counters with locks and keys.

The drugs were on 21 shelves which were hung with painted valance, paned yellow and red. The shelves contained 19 syrup

pots, 33 great gallipots, 20 pottle glasses, and many smaller glasses or bottles. 'Three stylled waters and their glasses', valued at 10*s*., were large bottles of waters distilled from rose leaves, dill seed, or other aromatics. Nine dozen phials are priced at 4*s*. Nine pairs of scales, ten ink pots, nine spatulas, and a stillatory with a pewter head complete the inventory. The total value of his drugs was £10, and of the shop fittings about £8.

His library comprised 43 medical works, including a Greek Galen, in 5 volumes, valued at £2, also a latin Galen and twelve other Galenic items. Brunfels 4 vols, compendium of Fuchs, Celsus, Varignanus, Aetius, Mesue, Avicenna, Mundinus, Rhasis, Paulus Aegineta, Hippocrates and Fernelius. His herbals were Brunfels, a 'parvum herbarium' and a 'hortus gallicus capegi'. Dr. Palmer has printed the catalogue in extenso, showing it to have been essentially the collection of a scholar.

A few years later Henry VIII, to whom England owes so many of her best institutions, provided the Cambridge faculty of medicine with its first and permanent head.

John Blyth of King's was the first of an illustrious succession of Regius Professors of Medicine, 1540–54. The stipend was £40 a year (in 1575). He married Alice, daughter of Peter Cheke, the esquire bedell.

In 1521 the name of Linacre was made known in Cambridge by the chosing of his translation of Galen's *de Temperamentis*, by John Siberch, a German, for printing with six other books in that year. His many virtues are summarized on an inscription that was placed upon his tomb in St. Paul's cathedral thirty years after his decease in 1524 by his admirer and follower Dr. John Caius (1510–73). Both are very great names in the history of English Medicine. Without Linacre there might have been no Caius. Not that they ever met, for Caius did not go up to Cambridge until five years after Linacre's death. But he followed him to Italy, and like Linacre read Greek manuscripts in the Vatican, studying medicine at Padua for 4 years, partly under Montana; his lodging for 8 months in the same house of Vesalius must have profoundly affected his outlook. On his homeward journey he became acquainted with Conrad Gesner.

The following are some of the more important events in

his life. In 1547 he became Fellow of the College of Physicians. In 1552 he published *A Boke or Counseill against the disease commonly called the sweate or sweatynge Sicknesse*—the first medical monograph in the English tongue intended 'for Englishe men not lerned'.

From 1546 to 1566 he lectured on Anatomy to the Barber-surgeons. From 1557 to 1569 he refounded Gonville Hall, and in 1564 obtained a grant of two human bodies for dissection.

Both Linacre and Caius 'in their humanity, their love of learning, their public and private generosity, are examples which have affected English physicians ever since' (Norman Moore).

John Herd (c. 1512–88). King's 1529, fellow 1532, M.D. 1558.

Henry Stansby, fellow of Jesus, commenced M.D. 1540, F.R.C.P. 1553.

John Hatcher, 1512–87, of St. John's, 2nd Regius Professor of Physick, was a most successful practitioner, if we may judge by his worldly possessions at his death. He was created M.D. in 1542 and shortly afterwards bought the site of the lately suppressed Austin Friary at the back of Corpus. In 1580 he became Vice-Chancellor.

His house was on a palatial scale, containing twenty-seven rooms, the largest of which was seventy yards long and nine feet high. Other rooms were 55 yards and 23 yards round. The walls were hung with tapestry or coloured cloth. In his 'shop' were several pairs of scales, 2 cwt. of lead, a pestle and mortar, and a settle. But elsewhere were 'two crystal stones', which recall the fact that Drs. Hatcher and Dee were contemporaries at St. John's. There were also 50 lbs of 'cipery' root (*Cyperus longus*) valued at 26*s.* 8*d.*, which was a remedy for dropsy. Also a marble stone to cast *manus Christi*, a kind of lozenge or cough drop.

He had 540 oz. of silver plate—much double gilt. Also a scarlet gown faced with red damask and lined with red baze, a silk grogram gown guarded with velvet and faced with coney, also velvet caps, both for night and day.

Galen in 5 vols. was valued at £3, Avicenna 13*s.* 4*d.*, Dioscorides 5*s.*, Rosa Anglica at 20*d.* He had the works of Fallopius,

Villa Nova, Gratarolus, Cardan, Albucasis, Benedictus Victorius. Dr. T. Bright's *Treatise on English Medicine*, 1580.

His daughter married Thos. Lorkin, M.D., who succeeded him as 4th Regius Professor of Physic (1564–91), and who also collected a fine medical library.

His great parlour was used in 1789 by the Professor of Botany as a lecture room.

Henry Walker (Gonville), M.D. 1532. 3rd Regius Professor of Physic c. 1555. Died in April 1564, bequeathing books to Caius College. It is presumed that George Walker, M.D., of King's, who died in 1597, was his son.

Robert Huicke (*d.* 1581), fellow of Merton 1529. College of Physicians c. 1536. M.D. Cambridge 1538. Physician to Henry VIII, Queen Catherine Parr, Edward VI, and Elizabeth. He took part in physic Act kept in Cambridge on 7 August 1564. See p. 253.

Richard Argentine alias Sexten, usher of Ipswich School, created M.D. Cambridge 1541.

Thomas Wendy was a fellow of Gonville Hall (1519–24) who achieved the rare distinction of attending Henry VIII, Edward VI, and Mary on their death-beds. Born about 1500 at Clare, in Suffolk, he went up to Cambridge and graduated M.D. at Ferrara. He was admitted F.R.C.P. in Dec. 1551. During the last ten years of his life, when he added parliamentary to his other duties, he seems to have had a town house in the parish of St. Mary Aldermanbury, for there on 13 June 1552, 'Mr. Thomas Wende Doctor of Phiscick and Margaret Atkyns' were married. And in 1560 'deceased Mr. Docter Wenday the xi of May and buried in Cambridgesheere the xxvij of May'. This entry in a London Register indicates that Munk and the *D.N.B.* are not right in assuming that he died at Haslingfield, of which Henry VIII had granted him the rectory in 1541. As a friend of John Caius and a benefactor of the College he is commemorated at Caius College on the anniversary of his death on May 11. With Drs. Over and T. (? Robert) Huicke he attested the Will of Henry VIII, a service for which each received a legacy of £100.

In the second half of the 16th century the plague broke out again with spasmodic violence. It is not without its

humorous side that when in 1556 infected houses were closed, and physicians must have been urgently in request, the government chose one of them, Henry Walker, M.D., to sit on a Commission for inquiring as to heretical books, and in 1557–8 it was settled by Convocation at Canterbury that in Natural and Moral Philosophy Aristotle only should be read at the Universities.

Nemesis followed.

In 1568 dispensation was granted to the Regius Professors so that they might be not required to lecture between Midsummer and Michaelmas owing to 'the contagiousness' of the season and 'daungerousness both for the readers and also for the hearers'.

In 1572 'the Physicke actes (by reason of the shortnes of them, which is but an houre a peace) are poasted over so slenderlie, that no man delighteth to heare them. Also, it is very undecent that Physicke should be reserved to the last ende'.

To which it was replied that formerly when Physic was taken first, the Divinitie disputations were largely unprofitable.

William Boyton (1524–1600), King's, M.D. 1562.

William Bullen, b. in isle of Ely. c. 1554 practised as a Physician at Durham. Removed to London in 1560, where he was imprisoned for debt. Died 7 Jan. 1575–6. Author of

1. *The Government of Health.* 1558, 1559, 1595. Dedicated to Sir Th. Hilton.
2. *Treatise on Healthful Medicines* (MS. lost at sea).
3. *Bulleyn's Bulwarke of Defence against all Sicknes, Sorenes, and Woundes that dooe daily assaulte Mankinde.*
4. *A Regimen against the Pleurisy Law.* 1562.
5. *A dialogue both pleasaunte and pietifull; wherein is a goodly Regiment against the Fever Pestilence; with a Consolation and Comforte against Death.* London, 1564. 12mo. 1573. 8vo. 1578.
6. *Doctor Bullein's dyet.* Lond. 8vo. 1585.

Philip Barrow, or Barrough, in 1559 held a licence to practise Chirurgery and in 1572 another to practise physic.

He wrote *The Methode of Physicke containing the Causes, Signs and Cures of Inward Diseases in Man's Body from Head to Foot.* London, 1590, 1596, 1610, 1617, 1624, 1634.

THOMAS LORKIN, b. Frindesbury, Kent, c. 1528. Fellow of Queens' and Peterhouse, M.D. 1560. 4th Regius Professor of Physic 1564–91.

Son-in-law of Dr. Hatcher but not so affluent, for although he had considerable personal effects, in the form of rings of gold, he had found it necessary to pawn his gilt-cup valued at £5. His library contained a larger proportion of English books than his predecessors' collections. He had Dr. Turner's *Herbal* 1568, valued at 5*s.*; Paracelsus' *Hundred and fourteen Experiments*; and a book entitled *The difference of the olde physic taught by the godlee fathers and the new from Galen* 1585, value 2*d.* He died at Cambridge, 1 May 1591, having bequeathed all his physic books to be kept in the university library in a great cupboard locked.

ROGER LEE, matric. at Trinity 1547, took his M.D. 1563, and practised at York.

RICHARD SMITH, matriculated St. John's 1553, licensed to practise physick 1564. President of College of Physicians 1585–8. Died 1599. Not to be confounded with Richard Smith, M.D., of Oxford.

THOS. BARWICK, Fellow of Trinity 1548–77. Practised medical art at Bury St. Edmunds. His brass at Fornham All Saints, Suffolk, is dated 1599.

JOHN COLDWELL, M.D. 1564, of St. John's.

1. *Medical Prescription.* MS. Tanner Bodl. NE. C. iii. 5, p. 156 seq.
2. Letter to John Hall, chirurgeon, *For the curation of a woman who had superabundant and unnatural flux of menstrua.*

GEORGE WALKER, King's, *b.* Cambridge 1533, *d.* 1597, s. of Henry W., M.D.

RICHARD REYNOLDS, St. John's 1546, Trin. 1548, M.D. 1566–7. College of Physicians rejected him as very ignorant and unlearned c. 1570. He was imprisoned until he paid a fine of £20 for having practised without licence.

THOMAS NEWTON of Trinity, Oxford, aged 13. Queens',

Camb. 1562, ret. to Oxford. *d.* 1607. He practised in Macclesfield and at Little Ilford, Essex.

1. *Direction for the health of Magistrates and Studentes.*
2. *The Touchstone of Complexions* (Transl. from Latin).
3. *Approved Medicines and cordial Precepts.* 1580.
4. *The Old Man's Dietary* (Transl. from Latin).

Thomas Randall, Fellow St. John's 1561, M.D. and Lynacre Lecturer 1577, F.R.C.P. 1584.

John Jones. Licensed to practise 1564; in practice till 1579. Author of

1. *Diall of Agues . . .* 8vo. 1566.
2. *The Bathes of Bathes Ayde; . . .* 1572.
3. *The Benefit of the auncient Bathes of Buckstones, which cureth most greevous Sicknesses never before published.* At the king's Mede nigh Darby 1572.
4. *Galen's Bookes of Elementes* 1574.
5. *A Briefe, excellent and profitable Discourse . . .* 1574.
6. *The Arte and Science of preserving Bodie and Soule in Healthe . . .* 1579.

William Baronsdale, St. John's 1551. Medical lecturer 1560, 1564. M.D. 1568. President of the College of Physicians 1589–1600. *d.* 1608.

Julio Borgarucci, M.D. (Padua), incorporated M.D. 2 July 1567 at Cambridge. Physician to the Earl of Leicester. *d.* 1580.

John Vulpe (Caius), a Hungarian, physician to Earl of Sussex. M.D. Cantab. 1569. Will proved 1589–90 (P.C.C.).

Reuben Sherwood (1542–99), M.D. King's 1561, fellow M.D. 1581. Practised and is buried at Bath.

John Beaumont, M.D., Trin. 1568.

Thomas Lakes (*d.* 1595), Christ's, M.A. 1564, M.D. 1571.

Thomas Turswell, educated at Eton and King's, where he was admitted fellow in 1569. Licensed to practise chirurgery 1572–3; physic in 1578. See p. 151.

Thomas Muffet, matric. Trin. 1569. M.D. of Basle. Probably practised as a physician at Ipswich.

1. *De Venis Mesaraicis Obstrvctis ipsarumque ita affectarum curatione.* 1578.
2. *De Anodinis Medicamentis Theses in medicor. Basiliens. Gymnasio propositae.* Basle 1578.

3. *De jure et praestantia chemicorum medicamentorum dialogus apologeticus.* Frankf. 1584. Prefixed to which are
Epistolae quinque medicinales.
Nosomantica Hippocratea. 1588. [See p. 340.
Insectorum sive Minimorum Animalium Theatrum.
Healths Improvement. 1655.

ABRAHAM FLEMING, Peterhouse, translated several scientific tracts from the Latin and left a MS. giving '*Reasons why a Priest may not practise Physic or Surgery*, as offered by Dr. J. Christopher to Dr. Hussy'.

LANCELOT BROWNE, matric. St. John's 1559, fellow of Pembroke 1567, licensed 1570, M.D. 1576.

In 1589 he and others were appointed by the College of Physicians to prepare the formulae of syrups, juleps, and decoctions for the Pharmacopoeia. He wrote an

Epistola Johanni Gerardo Chirurgo peritissimo et rei Herbarii calentissimo dated Westminster Cal. Dec. 1597. Prefixed to Gerard's *Herbal*, 1597.

He was principal physician to Queen Elizabeth and James I, and died shortly after 11 Dec. 1605.

THOMAS GRIMSTON, Caius 1573, M.D. 1601. *d.* 1608.

ANTHONY BACON was sick of the Plague at Trinity in 1574, and incurred the following expenses:

for anthonie beeing syck xijs vjd
more in the tyme of hys syknes vs vjd
in the tyme of anthonies sycknes for meate and other things xxiijs 8d
for meat from the Dolphin whilee Anthonie was syck xijs ijd
the potigaries byll as yt appeareth by the same by doctor hathchers consta xvs
almon mylk for antonie vjd

He survived and became M.P. for Oxford.

ROBERT HUICKE, M.D. 1578–9, presented Queen Elizabeth with two pots of orange flowers and candied ginger, receiving in exchange a gilt bowl. See p. 249.

EDWARD DODDING, fellow of Trinity 1563, M.D. 1576. That he practised at Bristol is shown by *A Report in Latin of the sickness and death at Bristol of a man brought home*

by Captain Frobisher from the north west 1577. MS. in State Paper Office.

JOHN BARRET, Trinity, B.A. 1554–5, created M.D. from Peterhouse 1577. *d.* 1578.

JOHN JAMES (*d.* 1600–1), Trin. Coll. M.D. 1578. Censor of College of Physicians.

THOMAS PENNY, M.D. 1582. In 1570 failed to satisfy College of Physicians of fitness to practise.

ROBERT WATSON, Queens' 1581, Clare Hall 1584/5, Queens' 1589, when he was licensed to practise, which he did at Braintree, co. Essex, with a due admixture of Astrology, see p. 152.

JOHN FARMERY, *d.* 1590. M.A. King's 1568, F.R.C.P. 1589, M.D. Leyden. In 1589 he was associated with Drs. Alston, Browne, and Priest in preparing the formulae of syrups, juleps, and decoctions for the Pharmacopoeia.

He lived and died in the parish of S. Mary Aldermanbury where his wife Anne bore him two daughters, Mary in 1588 and Elizabeth in 1589. Two years later we read in the parish register under date Feb. 27, 1592 that Mr. Edw. Lister, Doctor of Phisick and Fellow of King's College, married Mrs. Farmery late wyfe of John Farmery Doctor of Physick.

The life of Dr. EDWARD LISTER (*b.* Wakefield, Yorks., 1556, *d.* 1620), elected in 1574 to King's, was intimately associated with that of John Farmery. Both were King's men, both lived in the same London parish, they married the same woman, and were all three buried in the same church of St. Mary Aldermanbury. Lister became F.R.C.P. in 1594 and was physician to Elizabeth and James I.

Plague

In 1574 the Plague raged. It was stated to have been brought by a Londoner who attended Midsummer fair. It was arranged that the Old Clay Pits should be employed for the poor patients and their keepers. They were rented at 1*s.* per annum from the town clerk, Edward Ball, hence the name Ball's Folly (since Gonville Place).

Dr. Perne, the Vice-Chancellor, wrote a long letter on the *Plague* to Lord Burghley and in a postscript suggested

that Sturbridge fair should be granted to the University, they letting booths to the townsmen at a reasonable rent.

I take it my most bounden dewty to enforme your honor of the state thereof, especially in this tyme of sicknes, knowinge the singular care the which your honor doth beare to the good Governement and well doinge of the said universitie. Allthough I have of late in twoe severall lettres given your honor understandinge of y^e^ nomber of those which have dyed of the plage this yere sithence the begynnynge thereof untill this daie, & in what severall parishes theie have dyed, the first beinge sent to your honor by Mr. Redman the reader of Powles in London, the other by a Frenchman the reader of the Hebrewe lecter in Cambridge: yet for that the said plage is not as yet sesed, but in the beginnynge of this weke past did begyn againe to be dispersed in other places then it hath been heretofore, we were put in great fear thereof, of the which I thought to give your Lordship understandinge at this tyme, sithence which tyme (thanks be to God) there hath non dyed of the plage so far fourth as I understand. Allthough we must confesse that our synnes is the principall cause of this and of all other plages sent by Allmightie God, Yet the secondarie cause and meanes is that God did use to bringe the same, so far fourth as I do understand, is not the corruption of the ayer as the Phisitians saieth at this tyme, but partlie by the apparell of one that cam from London to Midsomer fayer and dyed of the plage in Barnwell, where the plage hath been and is now most vehement. The other cause as I conjecture, is the corruption of the King's dytch the which goeth thorough Cambridge, and especially in those places where there is most infection the which I will procure, so sone as we shall have any hard frost, to be clensed. There was order taken at the begynnynge of the plage by Mr. Doctor Whitegifte then vichancellor with the consent of the heads of the Colleges, for the breakinge up of the Colleges and for the forbearance of any common assembles untill after Christmas, and that such Schollers as should remaine in the colleges should kepe their gates shut for the avoydinge of the company of those that be infected with the plage the which do go abrode both in the day-time and in the night tyme, though there be never so good and streight order taken by us for the shetting up of the dores of those howses the which be infected,

havinge all necessaries provided for them and there familyes as well in Cambridge as allso in Barnwell. It appeareth that the poore folks in the Townes of Cambridge and Barnwell, seinge the good provision that is made for the relief of such as be infected with the Plage, that there desire is the contynuance of the same, and some other be of that perverse judgment that one Christian ought not to avoide the company of another that is infected with that disease of the plage, the which naturally, as a poyson doth infect except it pleaseth Allmightie God of his goodnesse otherwise supernaturally to dispose the ordinary operacion of his creaturs. Some in Cambridge who beinge alive did attempt God in this sorte are dead of the plage at this tyme, to the utter destruction of their whole howsholde and infecting of divers others. As the university hath in this tyme of discontinewinge susteyned greater loss in their lerninge then in the health of their bodies, for sithence the begyninge of the sicknesse (thanks be to God hitherto) there hath not twoe schollers been sicke of the plage, for the Townesmen have well lerned in this tyme of the absence of Schollers what great benefite theie received by the university, without whome the most parte of them do nowe confesse that theie should not be able to live, I am in good hope that Allmightie God, whoe hath of his justice striken both them and us for our amendment, that of his mercy he will here our humble peticions and staye this grevous plage that we may all studye to serve to the setting fourth of his glory. I do send to your honor a brief note of such as have died of the plage in Cambridge hitherto, with a mappe of Cambridge, the which I did first make principally for this cause, to shewe howe the water that cometh from Shelford to Trumpingtonford & from thence now doth passe to y^{e} Mylles in Cambridge, as appearith by a blewe line drawne in the said mappe from Trumpingtonford, (withowte any comoditie) might be conveighed from the said Trumpingtonford into the King's ditch, the which waie as appearith by a red lyne drawne from the said Trumpingtonford to the King's Ditch, for the perpetual scouringe of the same, the which would be a singuler benefite for the healthsomnes both of the universitie and of the Towne, besides other comodities that might arise thereby. I do trust in Almightie God, and I do greatly desire to see this thinge once brought to passe which hath been of longe tyme wisshed for of many. And thus

I praie Allmightie God longe to preserve your honor in most godly & honorable prosperitie. From Cambridge this xxi[th] of Novembr 1574. Your honors most bounden dayly Orator,

ANDREW PERNE.

On 30 Sept. 1575 the town and University entered into an agreement for the clearing of the town, and thus diminishing the risk of pestilence, and for the provision of leather buckets, hooks, ladders, and scoops for dealing with outbreaks of fire.

Among the physicians of the period who spread the reputation of Cambridge to a wider field were:

Dr. PETER TURNER (1542–1614) of Cambridge, who was for a short time (c. 1579–80) Physician at St. Bartholomew's Hospital. He was succeeded by

Dr. TIMOTHY BRIGHT in 1585 (Trinity Coll.), who knew but little of medicine but wrote a work on Shorthand. On one occasion the hospital apothecary complained of the costliness of the drugs prescribed by Dr. Bright. He eventually took orders and a living, invented shorthand, and played upon an 'Irishe harpe'. Died 1615.

Dr. RALPH WILKINSON (*d.* 1609), fellow of Trinity, M.D. 1573. Office bearer in College of Physicians. His MS. *De Urinis* is in the British Museum. He was also at St. Bartholomew's.

WILLIAM HARVEY (1577–1657). Incorporated M.D. 1602 at Caius and at Oxford 1642. Physician to St. Bartholomew's Hospital 1609. Physician to James I 1618.

Notwithstanding the obviously unsavoury nature of the town the splendour of the Elizabethan age was not without some reflection in Cambridge medical circles. One of these, Dr. THOMAS LORKIN, 4th Regius Professor of Physic, in 1590 feeling that his position merited such a distinction, obtained from Robert Cooke, Clarenceux King of Arms, a grant dated Nov. 13 of the following armorial bearings:

Az., a fess *ermine*, between 3 lozenges *or*, on a chief *g*, a lion [passant] gardant *or*, marked on his side with the letter M *sable*.

Crest. On the helm *or*, a wreath *or* and *azure*, a quinquangle *arg.*, called *Simbolum Sanitatis*.

On 20 Jan. 1596 the Corporation of the City of London wrote to request the Universities of Oxford and Cambridge to nominate two qualified persons for each of the Gresham Professorships of Astronomy and Geometry and Physic.

At Cambridge the fifth Regius Professor, c. 1591, was William Ward, 1534–1609, M.D. 1567.

In Ward's tenure of the chair the following took their M.D. degrees:

Edward Elwyn, C.C.C. 1579, M.D. 1595. Physician to the Earl of Salisbury.

Robert Sherman, Trinity 1575, M.D. in or about 1595. F.R.C.P. 7 Sept. 1599.

In 1597 Edward Lapworth was licensed. He died 1624.

In 1600–1 it was enacted that one Phisicke Reader, called the Queen's Reader, should read and interpret Hippocrates or Galen 'in such sort as shall seem meete for his auditory'. Given by her Majesty's bill assigned.

But the Plague visited Cambridge with renewed virulence.

The Seventeenth Century

Plague

There were buried on the [Jesus] Green 7 in October, 2 in November, 1 in March 1603–4. Sermons were discontinued.

Two years later a temporary act to prevent infection was passed, and all idle games were prohibited within 5 miles of the town or University.

A case of a rather different character was reported on February 4, 1604–5. A certain Knightley was suspected of having bewitched two young women, so that he was put in gaol and the young women, 'by his Majesties Speciall dyreccion', were sent to Cambridge. His Majesty's pleasure was that the Vice-Chancellor and certain Heads of Colleges should call in some 'skilfull Phisitions and learned Divines to consider their case and to minister unto them such things as shall be thought fitt for remedy of their disease if the cause be naturall. Disbursements for Dyet' or care were to be refunded, and because 'so many yonge men diverse out of Novelty may be desirous to see them, it is thought very convenient there be care had in placing the Maydens in the Howses of some Townesmen, with that

restraint that none be admitted unto them but suche as by you shall be thought fitt for the better recovery of their indisposicion'.

The physician consulted pronounced the disease natural, but 'the tyme of the yeare for Medicines proper for their disease to grow now very unseasonable, and the aire of the Country to be more convenient'. So the girls were sent home to their friends and £80 was paid for expenses. (Cooper.)

St. John's on 1 March 1605/6 gave leave to John Collins 'to travaile [3 years] beyond the seas for his increase in learning, and withall [we] have given him his grace to be Doctour in Phisicke' here or beyond the seas. [White Vellum book.] Dr. Collins must have benefited greatly, for he took his M.D. in 1608, and in 1626 became Regius Professor of Physic. His contemporary Helkiah Crooke, 1576–1635, St. John's, M.D. 1604, Physician to James I, paid no attention to Harvey's discovery of the circulation of the blood. He wrote *Mikrocosmographia, a description of the Body of Man* 1616 and was appointed Anatomy Reader in 1629.

Under the 6th Regius Professor, William Burton of King's, 1596–1623, the following graduated:

John Searle was licensed to practise chirurgery 1607.

William Forrester, M.A., of Queens' was licensed 1608, having previously practised physic in London without a licence. Many complaints were made against him.

Edward Tyson of C.C.C., M.D., F.R.C.P., F.R.S. (1651–1708). Comparative Anatomist. Incorporated at Cambridge in 1680. Anatomical Lecturer to the Barber Surgeons and Gresham Professor of Physic.

A notable figure was William Butler, M.A., who died in Cambridge on 29 January 1617–18 in the 83rd year of his age. He was born at Ipswich, and educated at Clare Hall of which he became a fellow. In July 1563 he was incorporated at the University of Oxford,[1] but he returned to Cambridge later on, and in October 1572 was licensed to practise physic. Though usually styled Doctor, he never took the degree of M.D.

His reputation as a physician was extraordinarily high.

[1] Wood, *Athenae*, i. 720.

Fuller (*Worthies of England*, ed. iii. 180) calls him 'the first Englishman who quickened Galenical physic with a touch of Paracelsus, trading in chemical receipts with great success'. That his services were appreciated is shown by the bequest of a cassock and doublet from Lord North and a gift of 24½ ounces of gilt plate from the King in March 1611.

In October 1612 he was sent for to attend Henry, Prince of Wales in his last illness, when he gave his medical associates an example of his bedside manner.

On Wednesday the eight and twentieth (of October) and fourth day of his sicknesse, in the morning came Master Butler, the famous physitian of Cambridge, a marvellous great scholler, and of long practise and singular judgement, but withall very humerous; who (whatsoever he thought) comforting him with good hopes that he would shortly recover and that there was no danger; yet, secretly unto others, did not let to speake doubtfully, (as they say his humour is,) that he could not tell what to make of it, and that he did not well like of the same; adding further, that if he did recover, he was likely to lye by it for a great while, with dyvers other like speeches; neither could he be perswaded all the time of his highnesse's sickness, to stay any longer than one houre, or thereabouts, every morning; and so in the afternoone to give his counsell and advice with the rest: what moved him I know not; whether he did mislike the French doctor's [Dr. Mayerne] company, or because the cure was not committed to him as chiefe, or being jealous and misliking his highnesse's disease, and therefore loved not to meddle too much in the cure (which I rather imagine;) or whether his health or humour impeached the same, I dare not judge; the curious may best learne from himself: yet having, at his coming, enquired what was done, he approved the same, and wished the continuance of the same proceedings untill a further judgement might be given of the same event.[1]

On the 7th day Dr. Mayerne advocated bleeding, but Butler would not consent to this till the following day, when the Prince was accordingly bled. Although one scandalous writer has not scrupled to cite Mr. Butler's

[1] Sir Ch. Cornwallis, *Life and Death of Henry P. of W.* (*Somers Tracts*, 2nd edit. ii. 236).

opinion that Prince Henry was poisoned, it appears that in common with other physicians he entertained no such suspicion.

In November 1614 the King, who had had a fall out hunting at Newmarket, sent for Butler to attend him, and in May 1615 he visited him in Cambridge. His attention had been drawn to Butler in consequence of a cure narrated by Aubrey, *Brief Lives.* A certain parson suffering from insomnia had taken an overdose of opium, which was like to have made him sleep his last had not Dr. Butler used the following remedy:

He was sent for by the parson's wife. When he came and sawe the parson, and asked what they had donne, he told her that she was in danger to be hanged for killing her husband, and so in great choler left her. It was at that time when the cowes came into the backside to be milk't. He turnes back, and asked whose cowes those were. She sayd (her) husband's. Sayd he, 'will you give one of these cowes to fetch your husband to life again?' That she would, with all her heart. He then causes one presently to be killed and opened, and the parson to be taken out of his bed and putt into the cowes warme belly, which after some time brought him to life, or els he had infallibly dyed.

Butler lived over the shop of John Crane the apothecary.

Sir T. Bodley was discouraged because he could not get Butler to come to him, or even to speak with him; for he says: 'Words cannot cure him, and he can do nothing else to him: for upon sight of his Water he sent him Word what Case he was in.'

About 1610–11 he treated Nicholas Ferrar, ordering him a spare diet and the greatest temperance all his life, but in the autumn of 1612 the trouble came back again. He then prescribed foreign travel—to prolong his life to age 35—'Let him go next spring. I will take care of him this winter.'

Butler was a benefactor to Clare Hall. He died in 1617 and was buried in Great St. Mary's, where his monument is a half-length effigy under an arch with one hand upon a skull and the other holding a book.

The occasion of the visit of James I in 1615 provided

the authorities with an excuse for tightening the bonds of discipline especially in the matter of Smoking.

'No graduate, Scholler presume to resorte to any Inn . . . or Tobaccoshop at any time during the abode of his Majestie here; nor doe presume to take tobacco in St. Maries Church or in Trinity Colledge Hall, upon payne of finall expellinge the Universitie.'

The Plague in 1630

So grievous was the visitation of the plague in 1630 that on May 19 a grace was passed discontinuing Sermons; to be followed on May 25 by a most doleful dissolving of the University, occasioned by the infection brought thither by a soldier or two dismissed not long since from the King of Sweden's Army in February. The death-rate at once assumed alarming proportions.

From February	to April 24	24 deaths.
	to May 15	30 ,,
	to May 25	7 ,,

Pitch and rosin were burnt in St. Michael's Church. Further measures were described by the Vice-Chancellor, Dr. Butts, in a letter to Lord Coventry, quoted below.

The King, Charles I, took up the case, and as the result of an appeal some thousands of pounds were collected in London for the relief of the distress in Cambridge. A pest-house was finished by the end of June and the holding of the customary fairs was abandoned.

On July 2 Joseph Mead, then in residence, wrote:

'Our fair is broken up and yet we have nothing of the plague. God grant we may not, but we are fearefull till the full moone be past.' The summer assizes were held at Royston. Mr. Mead writing on September 4 continued his narrative:

All our markets today would not supplie us commons for night. I am steward [of Christ's College], and are faine to appoint egges, apple-pyes, and custards, for want of other fare. They will suffer nothing to come from Ely. Eeles are absolutely forbidden to be brought in our market; so are rootes. You see what 'tis to have a physitian [John Gostlin, M.D., Master of Caius] among the heads. We cannot have leave scarce to take the aire.

I hear just now that two houses were shut up at Royston, on Thursday, for the plague, and the infected translated into the fields. . . . At Trumpington hath died three—one Peck, his wife and maid.

Birch's *Charles I.* i. 50.

A further letter dated 24 April 1630 from Mead of Christ's graphically describes the troubles in his college:

'Our University is in a manner wholy dissolved; all meetings & Exercises ceasing. In many Colledges almost none left. In ours of 27 Mess we have not five. Our Gates strictly kept, none but Fellowes to go forth, or any to be lett in without y[e] consent of the major part of our Society, of w[ch] we have but 7 at home at this Instant, only a Sizer may go with his Tutors Ticket upon an errand. Our Butcher, Baker, & Chandler bring y[e] provisions to the Colledg Gates, where the Steward & Cooke receive them. We have taken all our Officers we need into the Colledg & none must stirre out. If he doth he is to come in no more. Yea we have taken 3 Women into our Colledge & appointed them a Chamber to lye in together. Two are Bedmakers, one a Laundresse. I hope the next Parlement will include us in y[e] generall Pardon. We have turned out our Porter & appointed our Barber both Porter and Barber, allowing him a Chamber next y[e] Gates. Thus we live as close Prisoners, & I hope without danger.'

The Master of Sidney told the same tale. It was

'the most doleful dissolving of our University, and the most suddain dispersion of our Students that ever I knew, occasioned by the Infection brought hither by a Souldier or two, dismissed not long since from the King of Sweden's Army, in February last. So as, whereas this time was our chief time of the Year for Acts and Disputations, now our School-gates are shut up, and our Colledges left desolate and empty almost. There have died of this Infection, from the last of February till the 24th of April, 24 Persons; and since then till May 15, 30 more, and 7 more.'

Sturbridge Fair was prohibited by Royal Proclamation, 'that noe good means and providence maie be neglected to staie the further spreading of the Infection', and the Vice-Chancellor wrote a long letter to Lord Coventry:

'There are,' he states, 'five thousand poor and not above one hundred who can assist in relieving them.' It appears that the

inhabitants of the neighbouring villages would neither suffer an individual to leave the town, nor come themselves with a supply of provisions, so that there was danger of famine as well as of the plague. He concludes, after complaining of the conduct of the justices of the county, 'For the present state of the town the sickness is much scattered, but we follow your lordships counsell to keep the sound from the sick; to which purpose we have built nere 40 booths in a remote place upon our commons, whether we forthwith remove those that are infected, where we have placed a German physician who visitts them day and night and he ministers to them: besydes constables we have certain ambulatory officers who walk the streets night and day to keep our people from needless conversing, and to bring us notice of all disorders; through God's great mercy the number of those who die weekly is not great to the total number of the inhabitants. Thirty one hath been the highest number in a week and that but once. This late tempestuous rainy weather hath scattered it into some places and they die fast, so that I fear an increase this week. To give our neighbours in the country contentment, we hyred certain horsemen this harvest-time to range and scowre the fields of the towns adjoining, to keep our disorderly pore from annoying them. We keep great store of watch and ward in all fitt places continually. We printed and published certayne new orders for the better government of the people, which we see observed: we keep our court twice a week, and severely punish all delinquents.

'Your Lordship, I trust, will pardon the many words of men in misery. It is no little ease to pour out our painful passions and playnts into such a bosom. Myself am alone a destitute and forsaken man not a Scholler with me in College, not a Scholler seen by me without. God allsufficient (I trust) is with me, to whose most holy protection I humbly commend your Lordship with all belonging unto you.'

A considerable sum of money was collected at Exeter, and sent to Cambridge for the succour of those infected with the disease. By January 1631 the town was free from the distemper. 347 persons had died of the plague, 617 of all diseases, and the numbers of the University were greatly reduced for several years.

The lives of some of the physicians of Cambridgeshire have been investigated by Dr. Palmer of Linton.

John Furtho in 1633 bequeathed to Trinity, of which he was a fellow, twenty of his best books. 'If they should choose "Friar Bacon's" manuscript, they should be allowed to have it, but only on this condition: if the true owner ever claimed it, the College was to give it up and make a copy of it before parting.' £208 16*s*. in gold was found in his house and also so ominous an apparatus as 'my grinding stones and my Muller cushions to cut gold' which reminded Dr. Palmer of another fellow of Trinity who got himself hanged for clipping coin.

It was a time when money could be made by those who knew how to do it, for one of the Cambridge apothecaries, a Mr. John Crane, held land valued at £1,000 per annum. He died in 1652, having enlarged the schoolhouse at Wisbech. Among other benefactions he left £100 to be lent *gratis* to an honest man, the better to enable him to buy good fish and fowl for the university of Cambridge, having himself observed much sickness occasioned by unwholesome food of that sort. His epitaph in Great St. Mary's church calls him *Medicus et Pharmacopeus* and speaks of him as having enjoyed almost equal celebrity with his predecessor Dr. Butler.

The Regius Professor of Physic at the time was Dr. John Collins of St. John's, who would have been about sixty years of age and nearing the end of his life in 1634. This may be the reason for his name not appearing among those of the heads of colleges and others who compiled the congratulatory volume addressed to Charles I on his recovery from smallpox. To him Dr. R. Winterton succeeded in 1635 and forthwith wrote a letter concerning the careless manner in which the University had conferred degrees in physic and licences to practise in that faculty.

Fears of plague were again rife in 1636, and the King directed that fairs, which had been the means of infecting the town with plague, should not be held that year.

In the same year Francis Glisson of Caius became the tenth Regius Professor at the age of 39, and adorned the chair for forty-one years. It was perhaps through reading Harvey's work published in 1628 that he had been incited

to read medicine, taking his M.D. in 1634 and becoming Regius Professor of Physic in 1636. For a time he practised as a physician in Colchester, but in later years resided in London where he became Reader in Anatomy at the College of Physicians. His highly distinguished work on the Nervous System and Alimentary Canal will be described elsewhere. He was the first of a sequence of Caius men to hold the Physic chair, which after his tenure fell to members of the college of William Harvey more frequently than to those belonging to all the other colleges in the University; Trinity men being conspicuous by their absence. Glisson said that Wallis of Emmanuel 1635 and fellow of Queens' was the first of his 'sons' to defend the new doctrine of the Blood (Hearne's *Langtoft*, I cl.).

One of his first official acts as Regius Professor was to sign the certificate on which the Vice-Chancellor granted a Licence to the Registrar of the University, James Tabor, M.A., and his wife to eat flesh in Lent, they being in a weak and infirm state of health in 1638 (Master's *Hist. of C.C.C.* 387).

In 1646 Plague broke out again. The future Archbishop of Canterbury, William Sancroft of Emmanuel, wrote to his father on May 4 reporting five deaths in the town and one at Jesus Green, but that the University was not much disturbed. On May 11 he wrote again:

> God be praised, there is none dead either here or at the Green since I wrote last. On Saturday there was some fear of Dr. Bainbrigg's family: a servant of his was taken with a great swelling under her ear, and much was talked, and they kept from Church on Sunday, but all is well there; the occasion was a plaster applied for the toothache, which drew thither that extraordinary flux of humours.

Special grants of money had to be made in 1654 to provide Dr. Francis Glisson, Professor of Physick, all moneys in arrear for his fee (*State Papers Domestic*).

It is not known that he engaged in active teaching at Cambridge, but he came up from time to time 'to keep acts' when candidates presented themselves for the degree of M.D. Among these would have been Thomas Arris,

EDWARD ARRIS AND CHARLES SCARBOROUGH

son of Dr. Edward Arris,[1] Master of the Barber-Surgeons Company, and Sergeant-Surgeon to King Charles I, who entered St. John's in 1639, aged 17, and took an Oxford M.D. in 1651. Also that able student, JOHN MAPLETOFT (1631–1721) who came up to Trinity in 1648 and took his M.D. in 1667. He was closely associated with Sydenham in medical practice and translated his works into Latin. In 1675 he was appointed Gresham Professor of Physick.

To Glisson's credit be it said that he stuck to his professional duties in London during the great plague of 1665, and was appointed President of the College of Physicians (1667–9). In 1675 he was obliged to appoint Dr. Brady, Master of Caius, as his deputy at Cambridge. He died in 1677.

Glisson published *De Rachitide sive morbo puerili qui vulgo* The Rickets *dicitur, Tractatus* in 1650. This, except Caius's work on the Sweating Sickness, was the first monograph on a disease published in England. It was based on his own observations of enlarged joints and bent bones among children of Dorset.

The history of the following years constitutes one of the most important chapters in the history of England. Owing to their geographical positions Cambridge and the East became Parliamentarian, Oxford became Royalist.

A good story of the time is worth retelling:

Dr. Bowles, a physician of Oundle, cured 'a captain of ye Parliament side, yt had torne some Common prayer-books, who was sick of a dissentery. He caused some of ye leaves to be boyled in milke, gave it to his patient and it cured him. So he preacht to him ye evil of tearing so medicinall a book.' To a sceptic on asking him whether any other printed paper would not have done as well, he replied, 'No, I put in ye prayer for ye vissitation of ye sick.'

In Jan. 1655–6 £30 was ordered to be paid towards building Pest-houses.

A contemporary letter written by a poor scholar of Jesus

[1] A picture of Edward Arris and Charles Scarborough, by Greenbury, in the Barber-Surgeon's Hall, was copied in water-colours by G. Harding in 1818.

College to his mother in 1662 is of interest for the full description that it contains of his dietary at Jesus.

Neverthelesse sometimes we have Exceedings: then we have two or three Dishes (but that is very rare): otherwise never but one: so that a Cake and a Cheese would be very welcome to me: and a Neat's tongue, or some such thing, if it would not require too much money . . . Mother, I kindly thank you for your Orange pills you sent me . . .

My breakings-out are now all gone. Indeed I was afraid at my first coming it would have proved the Itch: but I am fairly rid on it: but I fear I shall get it, let me do what I can: for there are many here that have it cruelly. Some of them take strong purges that would kill a horse, weeks together for it, to get it away, and yet are hardly rid of it. . . . Sometimes I go to an honest House near the College, and have a pint of milk boiled for my breakfast. . . .

I remain your dutiful son

J. STRYP.

These for his honoured Mother Mrs. Hester Stryp widdow, dwelling in Petticoat Lane, right over against the Five Ink Hornes, without Bishops-Gate, in London.

(Sir H. Ellis's *Letters of Eminent Literary Men*, 177.)

During Michaelmas term of 1660 and 1661 JOHN RAY was in residence at Trinity; he enjoyed a great reputation for the care he took of the pupils who were placed in his charge, and especially when they were ill. It was a dangerous time. One newly admitted fellow commoner, Goring of Heydon, was brought up to Cambridge by his father, who

'went away on Monday about 10 of the clock in the forenoon, and left his sonne with Mr. Lynnett and myself, who, within an hour of his father's departure, I cannot say fell sick, but began to complaine. His disease proved to be the small-poxe, which notwithstanding all the care and diligence which could happily be used, through the mere malignity of the disease, heightened by the sudden change and excessive heat of the weather, he died about ten o'clock on Saturday night.

This gentleman never came into the hall, never wore his gowne after his admission. He was of a handsome countenance, of his father's temper and disposition, and great hopes. This

dismal event is to me, I thinke almost as great a grief and affliction as to his parents, and makes me far more willing to abdicate my pupils and knock them off, than before. If you happen to meet this Gentleman I pray assure him of what I have acquainted you with concerning my solicitude for and care of his son, which I know you will easily believe to have been as great as I pretend to. . . . The rest of my pupills are as yet well. I hope the infection will spread no further. This Gentleman most certainly brought it from London with him. If there appeare to be any danger I shall send home your cousin and the rest of my pupills who have not yet had that disease. Now that I have told you my story, I shall take my leave and subscribe, Sir, Your most devoted servant, Jo. Wray.'

Coll. Trin. June 11, 1661.

Address. 'Leave this at the red Lion in Thames Street near Billingsgate to be conveyed as above described.'

Courthope's cousin, mentioned in this letter, was Timothy Burrell, another pupil of Ray's at Trinity, who also fell sick about the end of June or beginning of July. Ray described his symptoms in another letter to Courthope.

'A new trouble assaults me, I mean the sickness of your cousin. He fell into a feaverish distemper about sixe weeks since, (I know not upon what occasion), which, after a fortnight's space, he hardly got quit of without either phlebotomy or purgation. But now again to my great sorrow and disquiet, by a very little error, he is fallen into the like distemper, which sticks more pertinaceously to him, and doth not so far as I perceive, yet, after seven days abate. . . . I pray, sir, speedily acquaint his friends with what I write to you; he himself did not write the last week as I wish he had. Had not I engaged myselfe before I knew of his illness, I would by no means have left him, though I doe not conceive any great danger, the distemper being not violent; the worst is that I do not see any signes of concoction in his urine, it continuing without breaking or sediment. I hope he will doe well again, but he hath a very nice and ticklish constitution of body and is easily put out of order. . . . My mind is full of this businesse.'

Many a young student is his own doctor. Newton tried his digestion and nerves very hard, by forgetting his meals

and sitting up working until all hours. At the age of 30 he was already turning grey. At this time 'His breakfast was orange peel boiled in water, which he drank as tea, sweetened with sugar, and with bread and butter'. His colds he treated by staying in bed and curing by perspiration.

Newton in 1692 was under the impression that he had not slept a hour a night for a fortnight together, and for 5 days together not a wink.

Result: nervous irritability; introspection and brooding over the injustice done him; and the obsession that he had no chance of preferment.

Infectious Plague broke out again in August 1665, and Sturbridge fair was prohibited. At Trinity the men were sent down on Aug. 8, 1665 until December and also for the whole of the second half of 1666 and for part of 1667.

It was no loss to the world, for one of the B.A.s used the method of Infinite Series for computing the area of the Hyperbola at Boothby in Lincolnshire.

On October 10 sermons and school exercises were discontinued. None ventured to continue in Corpus Christi College but Mr. Tennison (afterwards Archbishop of Canterbury), who with two scholars and a few servants was given doses of wine with a preservative powder, whilst charcoal, pitch, and brimstone were kept burning in the Gatehouse. It was this attack that caused Newton to leave Cambridge for Woolsthorpe, where the fall of an apple suggested to him the principle of Universal Gravitation.[1]

In July 1666 Mr. Thomas Warren, an apothecary living at the Golden Anchor and Hart in Basing Lane near Bread Street was appointed by the University of Cambridge to receive what the charity of well-disposed persons shall invite them to give for relief of the Poor of that place much visited with sickness.

Pest Houses were erected on Coldham's Common.

By this time the Plague had taught its lesson. Medical training was in certain cases esteemed as important as preparation for Holy Orders. If a medical student were likely to achieve distinction it was possible for him to receive a royal dispensation from taking Holy Orders, and,

[1] Corney, *Curiosities of Literature*, 2nd edit. 152.

if earnestly devoted to the study of medicine, yet to retain his fellowship. This happened on 19 June, 1668 in the case of MARTIN LISTER, M.A., fellow of St. John's College. The College was required to continue him in his fellowship until one of the physic places in the college became vacant. He received a M.D. at Oxford in 1683, but made the mistake of his life when he believed the Ashmolean Museum to be a safe repository for his wonderful collection of the type specimens of many species of Shells. His books, too, are no longer available for study where he gave them.

WILLIAM BRIGGS, F.R.S., elected a fellow of C.C.C. 1668; M.D. 1677. Author of *Ophthalmographia*; the first author to write on vision and on the anatomy of the eye.

JOHN HAWYS, M.D., fellow C.C.C. 1619; M.D. 1629.

JOHN HAWYS, M.D., grandson of J. H., fellow, C.C.C. M.D. 1688. This family were in practice at Wymondham for three generations.

As an example of longevity at this time, we may quote the case of Anne, widow of Mr. Atherton, who died on 2 August 1671 in the 102nd year of her age.

Glisson, the Regius Professor, was now getting old, and several persons were hoping to succeed him. Among others Dr. JOHN CARR (Christ's) wrote to Williamson on February 11, 1671:

'I have been Deputy Professor of Physic for Dr. Glisson these ten years, and managed the chair, so that he designed, and everyone expects me to be his successor. Now I have intelligence that one Dr. Brady is endeavouring to get the reversion without Dr. Glisson's knowledge or consent. His Majesty was moved two or three years ago on my behalf, and then it was thought fit that no reversion of such a place should be granted. I beseech you therefore to endeavour to stop it now, or if there be any likelihood of a grant, to move for me to my lord Arlington for the reversion.'

On the other hand, ROBERT BRADY, M.D., Master of Caius College, prayed the King for a grant in reversion of the Professorship of Physic after Dr. Francis Glisson. He appended an account of his sufferings as a loyalist, telling how he escaped to Holland where his brother and 22 others

were murdered. On returning to England he took the degree of M.B., but was prevented by Cromwell from taking that of M.D. With Sir Horatio Townshend's support he was eventually appointed Regius Professor in 1677–1700.

It is in keeping with the enquiring spirit of the age that several of the fellows of the Royal Society should have recorded the daily state of their health and medical treatment. Excellent examples are to be found in the notes of Robert Hooke and SAMUEL PEPYS, the latter of whom suffered greatly from digestive and eye troubles.

The Statutes relating to the exercises of Bachelors of Physic at the University were altered by the King.

CHARLES R.

Trusty & well-beloved we greet you well.

Whereas our trusty and well-beloved Robert Brady doctor in physick and our reader or professor of the same in our university of Cambridge, hath by his humble petition besought us to establish and appoint that the exercises of candidates and probationers for the degree of bachelor in physick may be according to that for the same degree in law (save that they still stand bound to one opposition as formerly), and whereas you the vice-chancellor of that our university with very many of the heads of colleges there, having certified that you do not know any inconvenience or disadvantage it can be to the university or faculty of physick if the exercise of candidates and probationers for the degree of bachelor in that faculty should be reduced to and established in the same state and condition that the exercise of candidates for the same in law are at this present by the direction of the university statutes, especially if the said candidates in physick do still stand bound to one opposition as formerly, also the most revered father in God our trusty and entirely beloved counsellor William, lord Archbishop of Canterbury having given his approbation of the said petition, conceiving it very reasonable and worthy of our favour;

We have therefore thought fit to order, establish and appoint and do by these presents order establish & appoint that the exercise of candidates for the degree of bachelor in physick be hereafter according to that for the same degree in law (save as

before excepted that they still stand bound to one opposition as formerly), any statute or custom of that our university to the contrary notwithstanding with which we are graciously pleased to dispense in that behalf. And our further pleasure is that these our letters be entered in the register of that our university to stand there as a rule for the future in the case above-mentioned. And so we bid you farewell.

Given at our Court at Whitehall the 8th day of April 1681, in the three and thirtieth year of our reign

By his majesty's command
L. Jenkins

To our trusty & well-beloved the vice-chancellor and senate of our university of Cambridge.

Sir Robert Tabor of St. John's, a very eminent native of Cambridge, died on Oct. 1, 1681. He was the son of John Tabor, M.A., who started life as Apprentice to Mr. Dent, an Apothecary of Cambridge, and 'had the good fortune and honour of first finding out the method of administering the Bark which before had been unsuccessfully applied: for happening to think of giving it in smaller Quantities, and more frequently than had been heretofore practised, he succeeded happily in the experiment; and upon his acquainting the great Sydenham with it, he ever after recommended that method only'.

'His reputation hereupon was raised so high, that on the Dauphin's being terribly afflicted with an *Ague* for a long time, which had baffled the skill of all the Physicians of France, Lewis XIV hearing of his fame, sent for him over, where he soon perfectly effected the cure and was handsomely rewarded by the King; who would fain have perswaded him to have taken up his abode in his dominions. But this being in no way agreeable to his inclinations Lewis, amongst his other benefits to learning and knowledge, purchased the secret of him, which after his decease he was at liberty to communicate to the Publick.'

An entertaining story is told of him on his first arrival at Versailles.

'The physicians who were about the Prince did not chuse to permit him to prescribe to their Royal Patient till they had asked him some medical questions: amongst

others they desired him to define what an intermitting fever was. He replied, "Gentlemen, it is a disease which I can cure, and which you cannot".'

Steward's *Anecdotes*, ii. 164.

The English Remedy, or Talbor's wonderfull secret for curing agues and fevers, sold by the Author, Sir ROBERT TALBOR,[1] *to the most Christian King, and since his decease, ordered by his Majesty to be published in France for the benefit of his Subjects, and now translated into English for the publick good.*

The Frenchman who published this book (Surgeon to the Duke of Orleans, and director of the College of new discoveries) acknowledges the great success of the remedy, but taxes the discoverer with ignorance and ambition, and treats him as an Empiric: whilst Dr. Gideon Harvey, in a small tract called *The Conclave of Physicians*, deals with him more harshly. Others say this discovery was accidentally made by administering to a patient a larger portion than ordinary, it having before that time been only taken in small quantities for strengthening the stomach; but the former, I am apt to think, is the more accurate account. Be that, however, as it will, he became so famous that the King conferred on him the honour of Knighthood, and he continued in great repute till the time of his death 1681.[2] (Collins.)

Mention must be made of the enlightened policy of the college of Peterhouse, where medical studies were encouraged with satisfactory results. Here it was usual for fellows to be advised to determine in one of the three superior faculties, and quite a few went 'on the Physick line'. Among them were Sir SAMUEL GARTH (B.A. 1679, M.D. 1691, Harveian Orator 1697), the celebrated author of *The Dispensary* in 1699, who was physician-general to

[1] Cf. *Journal de Scavans* 1682, where by mistake he is called Talbor.

[2] Sir Robert Tabor's epitaph in Trinity Church: 'Medicus singularis, unicus Febrium malleus, Carolo II ac Ludovico XIV, illi M. Britanniae, huic Galliae serenissimis Regibus, Ludovicae et Mariae Hispanarum ac Indiarum Reginae, serenissimo Galliarum Delphino, plurimisque Principibus nec non minorum Gentium Ducibus ac Dominis, probatissimus.'

the Army, a member of the Kitcat Club, and quite a figure in contemporary society.

Sir W. Browne (1692–1774), B.A. 1710, M.D. 1721, the editor of Gregory's *Elements of Catoptricks and Dioptricks.* Also the founder of two κατ' ἐξοχὴν Non-travelling Physic fellowships in Peterhouse.

Josias Clerke (1640–1714), Peterhouse, F.R.C.P., 1675. President 1708.

Samuel Jebb (1694–1787), Peterhouse. M.D. of Rheims. Librarian to Jeremy Collier.

David Pitcairn, Physician to St. Bartholomew's Hospital, the first to point out the relationship between rheumatic fever and heart disease (1749–80).

And in later years Dr. Bond, the sixteenth Regius Professor of Physick 1851–1872 (cf. Arnold Chaplin, *B.M.J.* 1928, i. 1109).

The Hon. Roger North, who resided one year at Jesus, 1667–8, has left the following *Digression on the Regimen of Health.* c. 1680.

I must needs say, that although I do not argue that I did right, yet I have found it very successful to me. For when I have been very ill, and with the symptoms of want of good temper, which makes folk run to doctors, as in or fearing a fever, I have let all pass, and eat and drank with my friends as usual, though uneasy and improper, being disposed to endure anything rather than submit and own myself sick that brought upon me the ordinary importunity of catechization, how I did, and this and the other medicine. When I have been forced to own an indisposition I have retreated all diet into water gruel, and not a little, but a very great quantity, which I thought would clear me, and I have ever found my distempers wear off of themselves. I never took preventive physic, nor let blood. About the time of the death of Charles II. it grew a fashion to let blood frequently, out of an opinion it would have saved his life if done in time. And being reduced to water gruel once, I was very much pressed by a near relation to a degree to make me angry. I answered, if she had a mind to a porringer of blood for her breakfast I had it at her service. This conceit, more rude than reasonable, eased me as much of trouble as breathing a vein in a plethora. And as to matter of complaining, I ever declined

it in other matters of fortune and success as much as in the concern of health. It was a sort of *braveur*, but with this reason too, that I did not see any good of it. And I had a contempt for the complaints of others, as at cards some will not be contented unless you grant them that none had ever such ill-luck as they.

And in business that which we call fretting, which is the same thing as complaining, only doth not always burst out, I have laboured to conquer it, and believe I have brought myself to as much apathy as to good or ill success as any have, and I own it partly to temper, which hath much of passion, but is not easily excited. And as fretting or being afflicted at successes is all error, I would as little endure it as I could. And this is to be opposed to the excess of the other extreme, which is more vain and more offensive, I mean ostentation. For complaint calls for help, but ostentation does no good, and reacheth at none, but vexeth others with envy, and against fretting and grief at ill-success, which is inward, set pride and joy, both impertinent extremes.

To conclude this matter touching my regime, or rather no regimen of health, I never was perfectly at ease till I had fixed in my mind two grand points of philosophy. First, that labour and pain was not an evil beyond the necessity we have of enduring; but life itself and the greatest ease of it is actual pain; and that labour as commonly understood with regard to a man's strength and spirits takes off the tedium of life, which compensates and overpays all the trouble of it, and then with the ease and refreshment that follows it brings an actual pleasure, And when pleasure is sought by adding to life, as the philosophers intend by the pleasures of sense; by heaping of objects of taste, ease, and venery, they waste the spirits, bring diseases, and lose their force; but labour is natural and nourisheth the body, keeps it sound, and giveth vigour to the pleasures of sense. Second, the other is, that it is in all cases and circumstances better to die than to live, and that it is all weakness and infirmity that makes us desire to live, and therefore the weaker the body and judgment the stronger is the desire of life, which we see eminently in very old and sick persons; wherefore, in sound and happy state of mind we have the greatest indifferency of life, and can put on the firmest resolution to die. We argue for life from the generality of the desire, as when we affirm the pain of even living. Yet say others,

we all desire it, as if the desire of life were by divine impress, whereas it is the result of fear, weakness, and pusillanimity. This opinion frees us from the greatest solicitude of life, the vast care and passionate concern of health, which afflicts the most vegete and athletic constitutions, and it frees us from fear of pain, because death easeth us, and indeed from all other cares and solicitudes of life, which were insupportable were there not a certain conclusion by death. What care could set us at ease under all the revolving mischiefs and disorders of powers, and accidents of fire, robberies, and injustices? If a man were sure to live five hundred years what could secure him that that long thread was not to be spun out in pain, want, misery, contempt, and sorrow? No, let my retreat be secure, death in due time, and I defy the world. But what is due time? When living neither is nor can be tolerable. I grant much pain will be reasonably sustained in prospect of mending life and the restoring it to ease, such as is commonly called so, as setting broken bones, and other hard cures, not to omit instancing the pox, which many improvidently, and some ignorantly, get; and being a disease if neglected certainly mortal, and undertaken in time certainly cured, but with great and long torment, we will excuse the weakness of human nature so far as to endure more pain than death usually brings to save life, and not to relieve nature in such cases by accelerating death. What I say of corporal afflictions and pains may as well be applied to mental, which grow out of the diseases of a man's estate or fortune; that will have wounds by hopes and casualties, as well as errors and bad conduct, and I blame not men who slave themselves (as the word is) to repair it. Nay, when either from spirit or education, the increase of what is provided becomes needful, to make it adequate to the ambition of the person, for the pleasure of hoping, or expectation of good is greater than any enjoyment. (*North's Autobiography*.)

At the close of the century the purging action of magnesium sulphate was studied for the first time by Grew of Pembroke.

Eighteenth-Century Medicine 1700–1750

It is not easy to estimate the extent to which the University was affected by the disabilities of the age—chief of which was 'that the education there should be either

theological, or at least not such as should train students and their teachers for any profession rather than for Theology' (Wordsworth). But in the eighteenth century medical studies seem to have been continued with scant enthusiasm, and we cannot recall any contemporary discovery in medicine by a Cambridge man that was epoch-making.

There were Physick Fellows at Peterhouse, two medical fellows at St. John's, and perhaps a fellowship for an M.D. may occasionally have been continued for foreign travel, as King Charles II did in the case of Henry Paman in 1662. An unpleasant feature was the friction that arose between the Universities and the College of Physicians. Their relations had been strained for many years over the question as to whether medical University graduates should have the right to practise in London without being licensed by the College.

On the other hand advances in right directions were made by the constitution of a proper Professor of Anatomy, by the foundation of a Hospital, and, after delay, by a regulated supply of corpses for dissection.

On 18 November 1701 the case of the College of Physicians against Dr. Levett of Exeter College, who wished to practise in London, was brought before Sir J. Holt, who ruled that a University graduate in Physic was liable to a penalty for practising in or within 7 miles of London unless he had a licence from the College of Physicians (Lord Raymond's Reports i. 472).

Old remedies still hung on, and medical topics were a usual item in ordinary correspondence, witness this letter from T. Burrell of Trinity to his old friend and tutor John Ray, now nearing the end of his useful life.

Sr,

The last letter you favoured me with came to my hands a great while agoe, and in some few moneths after, I returnd you my thanks for it by my good friend and neighbour. Mr. Middleton tells me he not long since heard of you & that you were still afflicted with those ulcuscula you used to complain of. A sober & ingeniose neighbouring Minister (who has a considerable insight into Physic), telling me by chance of a gentleman's

WILLIAM STUKELEY, M.D.
After Kneller, 1721

son near him who had a running sore in his back so long that it had almost brought him to the grave, & had had the advice of the ablest Physicians and Chirurgeons in the town without any success, was brought back into ye countrey. And at last by the prescription of a diet drink given by a poor woman was perfectly cured [when] ill by this.

Of Oak bark a quarter of a pound or more taken fresh from the tree, of Ribwort, Mousear, Comfrey (herb or root), Cinquefoile, Oak leaves, of each one handfull. Putt all with 3 or 4 galons of olle boiled as you doe Hops, & drink it as your ordinary drink.

I was desirous to have the Receipt, that I might impart it to you presuming that you might be well able to judge or be advised whether it might be safe to use it in your case. Sometimes it falls out that diseases which have baffled the greatest artists, have been cured by simple contemptible medicines. If this may be serviceable to you I should think myself very fortunate in being any ways contributory to the wellfare of one to whom I have the greatest obligation in the world, to be an

Affection^{t}. faithfull friend
& humble Serv^{t}
T. B[urrell].

29 Apr. 1701

N. Laxatives must be used in the course of your taking this diet drink.

MS. R. 4. 42 Trin. Coll. Cambridge.

The life of one of the more serious of the younger students of medicine of the time is graphically illustrated by the record of William Stukeley. After being admitted to Corpus Christi College on 20 Nov. 1703 Stukeley wrote, 'I turned my mind particularly to the study of Physick, & in order thereto began to make a diligent & near inquisition into Anatomy & Botany, in consort with Hobart, a senior Lad of our College was entered into that study . . . I contracted acquaintance with all the Lads (& them only) in the University that studyd Physic, & Swallow of Pembroke who took his Batchelor of Physics degree while I was there, & since practised near or at Bp. Stortford, now dead; Child of Magdalen who now practises

at Lavenham Suffolk, & Parry Humphry, who both took the same degree, the latter now lives in North Wales; Joseph Sparkes of St. Johns, who now lives at Peterburgh; Henry Stebbing of Katherin Hall who since took Orders, & has signalised himself agst. the Bp. of Bangor; Kitchener of Queen's College, since dead; Dr. Ashenhurst now living in Trinity College; Dr. Addenbrook now dead. I was acquainted with Dr. Crask, since dead, at Bury St. Edmonds.'

With these companions Stukeley went fossilising and simpling. 'We hunted after Butterflys, dissected Frogs, used to have sett meetings at our chambers, to confer about our studys, try Chymical experiments, cut up Dogs, Cats, & the like.' (Stukeley, *Diary*.)

The later educational career of a keen student of medicine early in the eighteenth century is well illustrated in his case. He took his M.B. degree 21 Jan. 1707–8; 'studyed anatomy under Mr. Rolfe, surgeon, in Chancery Lane; went for lectures of Chymistry to Seignr Vigani in Trinity College, and in Queens College cloyster, and tryed many chymical experiments and dissections, injections etc. in conjunction with (now Dr.) Stebbin, then studying Physick, of Catherin Hall; and had a chamber allow'd him in Coll.'

He studied the practical part of physic under Dr. Mead at St. Thomas's Hospital 1709. M.D. 1719. Admitted to the fellowship of the College of Physicians 1720 and in March 1722 read the Gulstonian Lecture upon the Spleen, which he printed in folio, together with the dissection of an elephant, with many copper plates, coloured to imitate nature. Being a good astrologer he recorded 'Under the following direction ⚹ ⊙, □ ♀ I studyd physick under Dr. Mead at London. Fell into a female scrape.'

His early life was crippled by hereditary gout, especially in winter, for which he used to ride on horseback in the spring for the recovery of his health, but at the age of forty-three he underwent a course of treatment with Dr. Rogers's *Oleum Arthriticum*, and 'it saved his joints. By this and other proper regimen he recover'd his limbs and health to a surprizing degree, and has ever since enjoy'd a

firm state of health, beyond any example in the like circumstance'.

One at least of the medical dons dabbled in politics, for in 1706 it is recorded that HENRY PLUMPTREE, Dr. of Physick of Queens' College, secured the expulsion of Thomas Tudway, professor of Music, 'for scandalous and Toriacall reflections on ye Queen'.

The teaching of the age is further reflected in a medical notebook of about 1710. The notes were grouped under the heads:

Aphorisms or General Maxims for *Lengthening Life, Preserving Healthe* and *Curing Diseases*, in *six sections*: Nature of *Animal Economy*: Nature and Cure of *Distempers in General*: Nature of *Medicines, and their Operations*: the *Dietetic part of Physic*: Nature and Cure of *Particular Distempers*.

The Universal Remedy or Some Short *Reflections* on *Regimen* and its Effects, touching upon *Hunger: Branches of Medicine: Milk, Seed and Vegetable Dyet: Liquors: Debauches, Pestilence or Plague: Madness, Lunacy: Epidemical Distempers*, &c.

STEPHEN HALES, fellow of Corpus or Benet Hall 1703, F.R.S. 1718, was a man of the widest interests—having not only the distinction of being one of the Fathers of Vegetable Physiology (see p. 383), but being also noted for his fertile medical and physiological studies. Between 1733 and 1743 he published:

Hydraulick and Hydrostatical Experiments on the Blood and Blood Vessels; also the nature of certain Concretions. In *Statical Essays*, vol. 2, 1733.

Admonition to Drinkers of Spirituous Liquors, ed. 2, 1734.

Experiments of Sea-Water, Corn, Flesh, etc.; containing many useful Instructions for Voyagers, 1739.

Observations on Mrs. Stephens's Medicines, 1740.

On Ventilation, 1743. *On Tar-Water*, 1745.

Crounean Lecture and Job. X. 11, 12.

On 2 March 1706–7 JAMES DRAKE, a native of Cambridge and M.D. of Caius, died; and later in the year his *Anthropologia Nova, or a new System of Anatomy* was published, though many of his other books were burnt.

A Professorship of Anatomy was constituted by a grace passed on 11 June 1707 in favour of George Rolfe.

The troubles of an ailing undergraduate are contained in the letter of W. Renew of Jesus College to the Rev. J. Strype. He was plagued with grievous sore eyes in Feb. 1709–10:

'I have been bloodied in ye Temple veins & in ye Arm, been purged almost a dozen times & been blistered, and used all ye remedies imaginable for this last q[r] of the year & have hardly diverted ye Humour, so much, but yt upon ye least Cold it threatens me with a return. I have left off all ye exercises as shooting, hunting, coarsing, football etc. which can possibly endanger my catching cold; so yt I hope I may have an opportunity of fixing to hard Study now; which I have left off so long. . . . To draw ye Rheum & humours from my Eyes I am advised to smoak very much, which I dare not let my Father know, he's so averse to it yt I beleive he had as live see me dead or at least blind (and to be so is death to a Student) as with a pipe in my mouth. I have smoaked, so yt I can receive no prejudice any other way than by his anger, but I'll take care to conceal it from him, if possible, whenever I take a pipe. . . .'

To assist Doctors of Physic to resist the College of Physicians who claimed the power of preventing University graduates from practising in London, the Senate passed a grace in 1715. In this Oxford concurred. But in 1716/17 the Court of King's Bench in the case of Dr. West decided in favour of the College of Physicians.

Yet London physicians were not always irreproachable, for even as late as 1726 one of George I's physicians certified to Mary Toft's having given birth to rabbits in his presence.

In 1719 plans for a proper hospital were under consideration. John Addenbrooke, M.D., of Swinford Regis, co. Staffs., died on June 7 at the comparatively early age of 39. He had taken his B.A. from St. Catharine's in 1701, M.D. in 1712, and is believed to have practised in Cambridge. He bequeathed £4,500 on trust, after the death of his wife, to hire, fit up, purchase or erect a building fit for a small physical hospital in Cambridge for poor people. His endowment was increased by £7,000 under the will of

J. Bowtell, bookseller, and it was made a general hospital in 1767 by Act of Parliament.

In 1721–2 more friendly relations with the College of Physicians were established, and the latter agreed to appoint their fellows entirely from the list of University Doctors, while Cambridge undertook to make her degrees in medicine strictly conformable with the statutable requirements. This terminated an age-long discussion. See a Latin letter to the President and Fellows of the College of Physicians 1 March 1722. *Stat. Acad. Cant.*, p. 413. Thirty years later (1753) it was decided in the case of Dr. Isaac Schomberg of Trinity that an academic M.D. cannot claim to be enrolled F.R.C.P. as of right. (Nichols, *Literary Anecdotes*, iii. 27 *n.*)

The provision of subjects for dissection was still so inadequate that on 24 Feb. 1723/4 the House of Commons ordered that it be an instruction to the Committee considering a Bill for the better viewing and searching of drugs 'That they have power to receive a Clause for the better enabling of the Faculty of Physick, in the University of Cambridge, to take the Bodies of Persons executed for Felony, and other crimes in the Counties of Cambridge and Huntington for anatomical Dissections.' This clause was ultimately withdrawn.

Among the physicians of this period were:

Geo. Wharton, b. 1688. Pemb. Coll., M.D. 1719, died from mortification of the bowels in 1739. He presented a portrait of his grandfather, Dr. Th. Wharton, by Van Dyck, to the College of Physicians.

John Beauford, Trin. Coll., M.D. 1728. d. 1750. (Munk.)

John Hollings, Magd. Coll., F.R.C.P. 1726. F.R.S. d. 1739. (Munk.)

John Gaspar Scheuchzer, M.D., b. Zurich 1702, was created M.D. Cambridge during the visit of George I in 1728. He was a good natural historian and protégé and librarian of Sir Hans Sloane, F.R.S. 1724, in whose house he died in 1729. (Munk.)

William Battie (1704–76), M.D., King's 1737. Practised in Cambridge. Lumleian Lecturer, physician of St. Luke's

hospital, and author of *Treatise on Madness* 1758, and *Aphorismi de cognoscendis et curandis Morbis* 1762.

Dr. John Burton (1710–71) was educated at St. John's College, and in medicine at Leyden. He was a founder of the York County Hospital; and author of a standard work on midwifery. He invented the obstetric forceps which is preserved by York Medical Society. He is held up to ridicule by Sterne in *Tristram Shandy* as 'Dr. Slop', as a bad-mannered Papist.

Alban Doran, *Burton* (*Dr. Slop*) *his Forceps and his Foes.* (Manchester 1913.)

William Heberden the elder (1710–1801), Linacre lecturer (1734–8), M.D. of St. John's (1739), gave an annual course of lectures on Materia Medica (see page 331) before he migrated to a London practice in 1748. One lecture was published: '*Ἀντιθηριακά*: *an essay on Mithridatum and Theriaca*' (1745). Dr. Johnson spoke of him as the last of the learned physicians—*Medicus vere Hippocraticus*. His *Commentarii de Morborum Historia et Curatione* was printed posthumously in 1802 (Munk, ii. 142), as was the *Introduction to the Study of Physic* by Paul Hoeber in 1929. His book of *Commentaries* was by far the most learned medical book of the eighteenth century, and the concluding passage is well worthy of quotation:

> To living bodies belong many additional powers, the operations of which can never be accounted for by the laws of lifeless matter. The art of healing, therefore, has scarcely hitherto had any guide but the slow one of experience, and has yet made no illustrious advance by the help of reason, nor will it probably make any, till Providence think fit to bless mankind by sending into the world some superior genius capable of contemplating the animated world with the sagacity shewn by Newton in the inanimate, and of discovering that great principle of life, upon which its existence depends, and by which all its functions are governed and directed.

Sir G. Baker and Dr. Gisbourne were among his pupils; another was Robert Glynn, later Clobery (1719–1800) of King's, who followed his example of lecturing regularly, c. 1751. He is said to have had so great a faith in the remedial powers of a blister, that he always began by ordering an 'Emplasma vesicatorium amplum et acre'.

His reputation at Ely stood very high, and when there, numerous persons from the Fens (where ague and fevers abounded) came for advice, which they always received gratuitously

In Michaelmas 1739 the health of the town does not appear to have been good, for on October 7 'We have had a very malignant Distemper of which have died two of St. John's, and of our own [Trinity] College, Sharp . . . and a great many others have been dangerously ill but are recover'd—myself having far from enjoyed my health all the summer' (*Letter* of T. Goodwin to Mr. S. Jebb).

Isaac Carew, a young fellow of Queens' College, died of smallpox on the 5 Apr. 1742.

George Baker (1722–1809), King's, Baronet 1776, Pres. of Coll. of Physicians 1785–96, proved that Devonshire colic and *colica Pictonum* were forms of lead poisoning; and Thos. Gisborne (1726–1806), St. John's, F.R.S., both became Presidents of the Royal College of Physicians.

Sometimes the interest taken in the more sensational cases led to their being described to the Royal Society as was done by Mr. Almond in 1744. Thomas Hall, known as the 'Willingham prodigy', was born at Willingham on 31 Oct. 1741.

At the age of 2 years 10 months he was 3 ft. $8\frac{1}{2}$ inches in height, and was so strong as to be able to throw from his hand a blacksmith's hammer of 17 lbs. weight; his voice was a deep bass; he had the marks of puberty, and whiskers on his upper lip. He grew at the rate of 1 inch a month until the end of March 1745; in the next 13 months he grew only 5 inches; in November 1746 his height was 4 ft. $5\frac{5}{10}$ inches; the length of his foot 8 inches, and the calf of his leg $10\frac{6}{10}$ inches in circumference. He then weighed 85 lbs. or 6 stone 1 lb. He died at the age of 5 years and 10 months on Sept. 3, 1747, having attained almost to the height and proportions of manhood. An account of this extraordinary boy was published by Mr. Dawkes, surgeon, in a pamphlet, *Prodigiosum Willinghamense.*

In 1748 Bachelors of Physick were privileged, like those of Law and members of the Senate, to be permitted to use the University Library.

The Work of Hales

Although Stephen Hales, who it may be remembered was a Doctor, but of divinity and not medicine, had repeatedly averred that 'it was not for him to meddle' in the province of men of physic, yet his intimacy with physicians often suggested the course of his investigations and several of his researches have been of enduring benefit to the practice of medicine.

Thus in 1733 he directed his attention to possible 'dissolvents of the stone in the bladder'. Specimens of human calculi, obtained from Sir Hans Sloane and Mr. Ranby, F.R.S., surgeon to the Royal Household, were treated with various chemicals, but although many disintegrated stones were removed from the body, Hales was unable to find any solvent which might be safely injected into the bladder without harm to the patient.

He was defeated by what is still an insoluble problem. But his experiments did lead to his inventing a forceps for the removal of calculi—*Hales's Bladder Forceps.*

I cut off the lower end of a strait *catheter,* which made it a proper Canula for a Stillet or Forceps to pass thro'; the lower end of the Forceps was divided into two springs, like tweezers, whose ends were turned a little inwards; these springs were made of such a degree of tenderness and pliancy, as not to bear too hard against the sides of the urethra by their dilatation.

When this instrument is used, the springs are drawn up within the *Canula*; which being passed into the urethra as far as to the Stone, the Canula must then be drawn back, so far as to give room for the Forceps to dilate; which dilated forceps being then thrust down a little further, so as to embrace the stone, then the canula must again be slid down, to make the forceps take fast hold of the stone, so as to draw it out.

Mr Ranby made repeated trials of the instrument and found it capable of extracting stones with great ease and readiness (Hales, *Account of some Experiments on Stones. Statical Essays,* ii, p. 251).

Another of his inventions was a device for 'conveying

liquors into the abdomen during the operation of tapping'. *Phil. Trans.* xliii. 20 and 502.

Another important work was on blood pressure, much of which remained unpublished until 1733, twenty-two years after his first experiment on blood pressure had been performed (Kennedy). Hales had sent his Haemastatical papers to Sir Hans Sloane, the President of the Royal Society, before 15 July 1732, and as they met with the general approbation of the Council of the Society, desired him to print them on 28 February 1732–3.

HAEMASTATICS; *Or, an Account of some Hydraulic and Hydrostatical Experiments made on the Blood and Blood Vessels of Animals* was dedicated to King George II. Its merit was so generally recognized in influential quarters that the University of Oxford conferred upon him the degree of Doctor of Divinity. He was elected to the Council of the Royal Society, and later became one of the Trustees for the colony of Georgia.

In 1744 Bishop Berkeley of Cloyne had added his testimony to the virtues of the latest remedy, Tar Water, in his *Chain of Philosophical Reflections and Inquiries concerning Tar Water,*[1] and a 'Tar Water Warehouse' was opened behind the Thatch'd House Tavern in St. James's Street. The litterateurs of the day, Richardson, Sterne, and Henry Fielding, all wrote up its efficacy, but Hales analysed its constituents according to their rates of solubility and criticized the unscientific methods adopted in its preparation, urging that care should be used in the proper adjustment of the proportion of constituents, in the hope that 'the Light given by these Researches, might be of use in skilful hands, for regulating and adapting the due Proportions of the acid and oily Principles, to different Cases and Constitutions'. But 'This is the proper Province of the Physicians which I am no ways qualified to meddle in'.

[1] '*An Account of some Experiments and Observations on Tar Water: wherein is shown the Quantity of Tar that is therein. Which was read before the Royal Society. To which is added a Letter from Mr. Reid to Dr. Hales, Concerning the Nature of Tar, and a Method of obtaining its* Medical Virtues, *free from its* hurtful Oils; whereby also the strength of each Dose may be the better ascertained. 1747.'

Life on Ships

In Hales's capacity of a Trustee of the new Colony of Georgia various problems connected with the comfort and health of emigrants on ships became a subject of special study. His efforts were directed towards mitigating evils arising from overcrowding, contaminated water, stench of the bilge, and the nuisance of livestock carried between decks.

His *Philosophical Experiments; containing Useful, and Necessary Instructions for such as undertake Long Voyages at Sea; showing how Sea-water may be made fresh and wholesome, and how Fresh Water may be preserved sweet; how Biscuit, Corn etc., may be secured from the Weevel, Maggots, and other Insects; and Flesh preserved in Hot Climates by salting Animals whole; to which is added an Account of several Experiments and Observations on Chalybeate or Spring-Waters, with some Attempts to convey them to distant places, preserving their virtue to a greater degree than has hitherto been done; likewise a proposal for cleansing away Mud etc., out of Rivers, Harbours, and Reservoirs*, London 1739, were issued under the imprimatur of the President of the Royal Society, Sir Hans Sloane, in 1740.

Some seafaring persons, he tells us in the preface, had complained to him of the 'very bad stinking Water' they were obliged often to make use of at Sea, and in one case experience on an East India ship where 'for want of fresh Water, the Ship's Crew was sustained fourteen days, with distilled Sea-water, which they distilled off at the rate of 10 gallons a day'.

These experiments led him to recommend the addition of acid to fresh water or distilled sea-water to prevent putrefaction.

For the general Disinfection of Ships he strongly advocated the general use of sulphur. Thus both 'pestilential infections of the ship and of the men might be counteracted by fumigation with sulphur, though the latter would need to have their faces covered with respirators consisting of folds of cloth dipped in potash'. (*Gent. Mag.* 1754, xxiv. 243.)

For the Preservation of Meat he advised the injection of

brine into the arteries might give a better result than the mere soaking in salt water. A demonstration of the method was given to the Lords Commissioners of the Admiralty at the Victualling Office on 17 April 1736.

Having furnished my parishioner, Mr. Macpherson, then Purser to the Honourable Admiral Boscawen, in his expedition to the East Indies, with a brass cock proper to fasten to the great descending artery on the left side of the back bone at the small of the back; he made trial at Madagascar on four oxen in the mid-day heat, by injecting brine thus for four or five minutes only; for it immediately flows to the extremest parts and pervades all the flesh to such a degree as to make it readily taste salt, when cut in proper pieces to be salted and barreled. This they fed upon for two months on the voyage home till it was all eaten; it continued good till the last. This method of preserving flesh in hot climates will therefore be doubtless of service especially to sea-farers. (Hales, *Ventilation*, 1758.)

In 1751 new medicinal waters were discovered at Glastonbury, and, like others at Godstone in Surrey, were much boosted in the papers. Hales analysed both and found them to possess no other properties than those of common spicy water. Thus he, 'from the pure love of truth and humanity, detected the impositions of those, who would have recommended common water to the afflicted, as a specific for all disorders'. The description was entitled *An Examination of the principal Purging Waters, especially that of Jessop's Well.* (*Phil. Trans.* 1750, xlvi. 446.)

Typhus versus Ventilation

About the middle of the 18th century it was believed that the tremendous mortality among the prisoners in the Savoy and Newgate prisons who had caught the 'Gaol Distemper', as Typhus fever was then called, was due to the noisome air in which they were confined. For the transmission of typhus by lice was not then suspected. As a part of the Savoy was also used to lodge men pressed for military service, who there contracted infection and carried the infection to regiments on service, the Secretary for War bethought him of Mr. Hales's ventilators.

'The good Doctor, by desire of the Secretary of War, was

today [June 29, 1749] at the Savoy Prison, to direct a proper place for the erection of a large Ventilator.'

The result was so successful that the death rate from infectious Gaol-Distemper was reduced from 50 or 100 per annum to a very few, and a similar system of ventilation was introduced into several of the county prisons and hospitals, and into St. George's Hospital in London. Hales was, however, only fair when he noted that

> what contributes the more to the present Healthiness of the Place [i.e. the Savoy] is that Mr. Hayward, the Master of the Prison, continues with the same Care and Zeal to keep it clean. And, the more effectually to cure the Wards of any Infection, he burns, as I desired him, every six weeks two pounds of Brimstone in the larger Wards, and a Pound in the smaller Wards. (*Gent. Mag.* 1749, xix. 282.)

The Lord Mayor ordered that some of the wards of Newgate should also be provided with ventilators, which were operated by man-power. This was apt to be intermittent, so that Hales adopted the following device:

> The Velocity with which the wind rushes into the Trunk is so great, as to twirl fast round a little Wind-mill placed at the Mouth of the Trunk. And in Cases where such a Windmill cannot be seen by the Workers of the Ventilators, then the Windmill may be made to make a very small tinkling bell to sound as was done at *Newgate*. This is found to be of considerable use in diverting, and thereby encouraging those who work the ventilators to persist in working; without which sensible Amusement they are apt to be discouraged from working the Ventilators; because, as it has been found by Experience, they are apt to look upon it as working to no purpose, since they can see no visible Effect that it has on the invisible Air. It is found to be of use, not only to divert and amuse those who work the Ventilators, but also to let the patients in each Ward know that they have their due proportion of Ventilation.

A terrible tragedy in the Spring Assizes of 1750 drew public attention to the danger, when the Lord Mayor, two judges, and 61 other persons lost their lives by fatal infection in court at the Old Bailey. Dr. Hales was immediately

consulted by Mr. Sheriff Janssen, with the result that the London jails were thoroughly cleansed, three cartloads of the most abominable filth being carried away from Newgate alone. All jails were thoroughly washed out with vinegar, and the prisoners before being brought to court for trial were ordered to be washed likewise. The court room in Old Bailey (to which nothing had been done for 30 years) was scraped, cleansed, and washed with vinegar, and Hales had certain herbs burnt therein for some days before the sessions began. (*Gent. Mag.* 1764, xxxiv. 17.)

In 1750 the Royal Society was consulted as to a good means of improving the state of ventilation of prisons, and in October Dr. Hales and John Pringle were instructed to inspect and report on the pestiferous wards of Newgate. Hales recommended the fixing of large Ventilators to be worked by a Windmill, as had been done on board a Man-of-War at Deptford. 'I am the more desirous' he wrote to Janssen in July 1751, 'to have it done in *Newgate*, not only for the sake of the prisoners there, but also as a laudable Pattern, not only for the rest of the nation but for the benefit of the world. . . . I am therefore persuaded that the opulent and renowned City of *London* will not long hesitate about it.' See p. 326.

The work was put in hand. Hales's new ventilators were installed in an upper room over the great gateway, and the windmill was erected on the leads overhead. However, during the construction seven out of the eleven men employed were found to have been taken ill of typhus. The matter was investigated by Dr. Pringle who communicated an account to the Royal Society.

A boy had been forced 'to go down into the great trunk of the ventilation, in order to bring up a wig one of the workmen had thrown into it'. As the machine was working at the time, he had almost 'died of the Stink before they could get him up' and had been taken ill of the gaol distemper that night. (Clark-Kennedy, *Hales.*)

In a later report—June 1752—Drs. Pringle, Knight, and Hales reported that the ventilators worked by the windmill drew 'like large heavy Lungs, foul air from the wards at the rate of 7,000 turns per hour'. The number of deaths

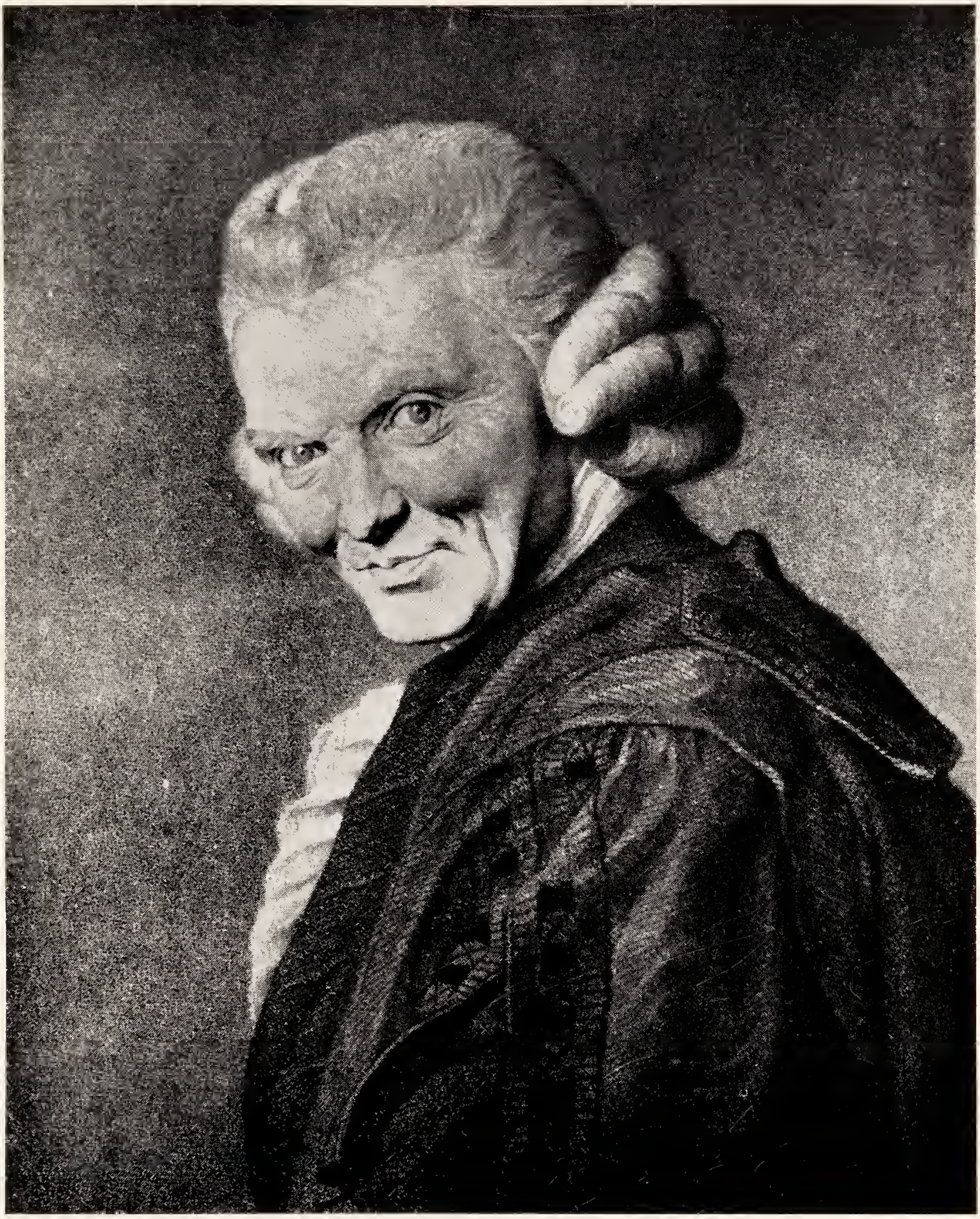
at Newgate was reduced from 7 or 8 a week to about 2 a month.

Knowing, as we now do, that Typhus is due to lice which carry the infection, and not to 'bad air', we realize that the ventilators could never be a perfect cure, but it is likely that the introduction of ventilation into the hotbeds of disease was a step that led to a higher standard of cleanliness and sanitation and thus did much to check the spread of the disease in hospitals and prisons. Hales's system of ventilators was too cumbrous to hold its own against later inventions and was soon displaced by the greater convenience of the application of steam power, and later by the electric fan.

During the latter years of his life Hales turned his thoughts to a number of purposes to which his Ventilators might be applied. These included the preservation of corn in large granaries, by keeping it dry and free from insect pests; also the drying of gun-powder at the powder mills; and the dispersing of deleterious gases and explosive 'damps' in mines; and lastly, at the suggestion of Mr. Littlewood, a Chatham shipwright, 'sweetening stinking water by blowing a shower of fresh air thro' a thin pipe, full of small holes, layed at the bottom of the water'. This suggestion led Hales to the discovery that when air is forced through boiling water, the quantity of the distillate was more than double. This very important fact is now widely employed in manufacturing processes. The title of the paper was *An Account of a Useful Discovery to Distill Double the Usual Quantity of Sea-Water, by Blowing Showers of Air up through the Distilling Liquor* (*Phil. Trans.* 1756, xlix. 312).

His 'pipes', by means of which pure hot air was supplied to hot houses for tropical plants at Kew, were a further development of his work on Ventilation. A derived invention was his 'engine which with the help of a pair of bellows, blows up cream into syllabub with great expedition', which gave great satisfaction to the children of the Princess of Wales at Leicester House.

Another considerable figure was Dr. Robert Glynn, fellow of King's, B.A. 1741, M.D. 1752, *d.* 1800, who



ROBERT GLYNN CLOBERY, M.D.

By courtesy of the Cambridge University Press

arranged the following course during the years before taking his M.D. degree.

On the 14th of March, 1750–1
Will begin
A Course of Lectures
on
The Medical Institutes

I. On the Animal Oeconomy.
II. On the Operations of Medicines.
III. On the History of Diseases.

By R. Glynn

> Gentlemen who propose to attend these Lectures are desired to call upon Mr. Glynn at King's College.

And later:

> On Monday, March 2nd 1752. Medical Lectures on the Structure and Use of the Principal Organs of the Human Body, will begin at 3 p.m. Anatomy Schools. 1st Course 2 Guineas; 2nd, 1 Guinea.

He was a very familiar figure in Cambridge, where he had a considerable practice, the poet Gray being among his patients. He was noted for many kindnesses to the poor. He went about dressed in a scarlet cloak and three-cornered hat and with a gold-headed cane. In addition to Glynn's favourite panacea, 'emplasma vesicatorium amplum et acre', one of his prescriptions is recorded by Cole:

'Being ill with St. Anthony's fire eruption about my shoulders, and gouty humours flying about me, I sent to Dr. Glyn for his advice.'

The prescription ordered was a teaspoonful of cinchona bark in a large tumbler of chamomile tea twice a day. This was in May 1779. In the following March, Cole was bled for his cold.

In Mathias's *Pursuits of Literature* he is distinguished as 'dilectus Iapis' 1796. There are portraits of him in the libraries of Magdalene and Caius.

On 6 October 1766 Quadruplets were born to Henry Coe, shoemaker of St. Sepulchre's parish. 16 sponsors walked in the

procession. The mother recovered, but three children died at the ages of 2, 15, and 20 months respectively—the fourth, Sarah, grew up, and was alive in 1800.

In 1766 the Trustees of Addenbrooke's Hospital or Infirmary reported that their funds were exhausted, so that the Vice-Chancellor and Mayor issued a circular letter requesting subscriptions. But more material help was given when on May 20 of the following year the Royal assent was given to 'An Act for establishing and well-governing a General Hospital, to be called Addenbrooke's Hospital, in the Town of Cambridge'. It was therein enacted that the physician and surgeons to be appointed to the hospital should and might act as governors at all general courts.

Among minor events may be recorded that in 1770 T. Okes published a volume of extracts from Hippocrates with a new Latin translation, notes, and emendations, incorporated in two Latin dissertations delivered in the Schools. Physicians have often been ready to assist classical scholars.

On 1 March 1774 Sir William Browne, M.D., President of the College of Physicians, died, leaving money for a scholarship in classics at Peterhouse.

Russel Plumptre, M.D., was buried in 1793 in the North aisle of Great St. Mary's church.

An important issue was decided in 1797 when the Court of King's Bench decided in favour of the validity of the by-laws of the College of Physicians which restrain others than doctors of physic of the Universities from being elected fellows.[1]

In the same year W. Hyde Wollaston, whose name is so well-known as a chemist and physicist, showed that Calculi found in the bladder might consist of calcium phosphate, magnesium ammonium phosphate, and calcium oxalate, to which he added cystin in 1810.

In 1798 the realm was in danger, and among subscribers of £100 each for its defence were Busick Harwood, M.D., Professor of Anatomy and Captain of the Cambridge Volunteers; Robert Glynn, M.D., fellow of King's College;

[1] The King *v.* the President and College of Physicians. *Durnford and East's Reports*, vii. 282.

and Sir Isaac Pennington, M.D., Regius Professor of Physic.

In 1799, according to Dr. T. Young, F.R.S. (Emmanuel), there were no medical Lectures at Cambridge except those of Professor Harwood, which were addressed to a miscellaneous audience.

Mr. Okes, the surgeon, attended the case of Elizabeth Woodcock who on her return to Impington from Cambridge Market on Febrary 2, 1799 was enveloped in a snow-drift under which she was confined for nearly 8 days and nights. She lost all her toes and most of the fleshy part of her face, but was deemed to be in a state of convalescence by April 17. She died in the following July through intemperance.

On 6 February 1800 Robert Glynn Cloberry, M.D., senior fellow of King's College, died in his 82nd year. For many years he had been practising as a physician in Cambridge. He left legacies of £100 each to Dr. Busick Harwood and his wife.

The Registers of the Church of St. Sepulchre sometimes recorded facts of medical interest of which we have not seen other mention, as for example on

July 10 1804 buried John, son of John and Mary Nourish. N.B. It was quite a *lusus naturae*, having no arms at all, and the feet, legs, and thighs crushed into the body.

1815. Owing to an outbreak of fever in several colleges and in the town, a grace was passed on May 3 permitting undergraduates to keep their term in absence.

On May 24 the physician of Addenbrooke's Hospital put out a declaration:

We, the undersigned, hereby declare, we do not know of any fever now prevailing in Cambridge.

And as far as we have been able to observe, the feverish complaint which has sometime back prevailed here, was not of a contagious nature.

I. Pennington M.D. T. Ingle M.D. J. T. Woodhouse M.D.	Physicians to Addenbrooke's Hospital.

Cf. Th. Verney Okes, *Observations upon the Fever lately prevalent in Cambridge.*

About 1820 the Examination System was being overhauled, with the result that the previous examination of candidates for the degree of M.B. was established in 1822, to be held in 1824 for undergraduates who had come into residence in 1822. Also after 27 Feb. 1829 M.B. candidates were required to be examined by the Professors of Anatomy, Chemistry, and Botany in addition to the Regius Professor of Physic, and to attend lectures of those professors and of the Downing Professor of Medicine.

A writer in the *Quarterly Review* for 1827, p. 235, noted that of all the Physicians in practice in England (300 L.R.C.P.s) about 100 had been educated at Oxford or Cambridge, but of 6,000 M.R.C.S. not 6 were University Graduates.

Addenbrooke's Hospital was enlarged by the addition of two wings in 1828, and the collonade in front was erected from a design by Charles Humfrey Esq.

In 1831, owing to a cholera scare, a Board of Health was established consisting of the V.C. and Mayor with 7 members from University and Town, six physicians and 14 surgeons.

A grace for modifying subscription to the 39 articles by medical graduates was proposed on 12 Feb. 1834 by Dr. Cornwallis Hewett, Downing Professor of Medicine, but this grace was rejected.

Candidates for the degree of M.B. were required to deliver to the Regius Professor of Physic certificates of attendance at Medical Lectures and of practice at some well-known hospital for 2 years; also to take out a licence to practise that faculty in the term after admission to the degree (5 March 1834).

Candidates for the M.D. degree were required to satisfy the Regius Professor of Physic, Professor of Anatomy, Downing Professor of Medicine, and a Doctor of Physic to be nominated by the V.C. and approved by the Senate (Grace of 1 Apr. 1841).

The 500th anniversary of the foundation of Gonville and Caius College was celebrated on 28 January 1848. Dr. Paris, President of the College of Physicians, was present.

15 November 1849 was a day of General Thanksgiving for the removal of the *Cholera.*

In 1851–2 the old Hospital of St. Anthony and St. Eligius (founded c. 1361) at the south end of Trumpington Street was purchased and its site thrown into the street. A new hospital was erected in Henrietta Street at a cost of £1,075, of which the materials of the old building produced £27 16*s.* and the site £300.

On 30 August 1852 the University Commissioners reported at length on many points and in favour of reforms affecting the faculty of Physic and of the establishment of a Board of Medical Studies.

John Ayrton Paris, M.D., died on 24 Dec. 1856 in Dover Street, London. He was born in Cambridge on 7 Aug. 1785, son of John Paris, organist of Peterhouse. He began to study medicine at the age of 14, and was entered at Caius, taking his M.B. in 1808, and M.D. in 1813. When only 22 years of age he was elected Physician of the Westminster Hospital. Later he moved to Falmouth, where he established the Royal Geological Society of Cornwall. He invented the Vamping Car which obviated the risk of a miner striking fire from the rock. Returning to London in 1810 he practised for 45 years as a physician and was elected President of the College of Physicians in 1844. He wrote a *Life of Sir Humphry Davy*; also on *Diet & Medical Jurisprudence & Medical Chemistry* (cf. *Lancet*, 3 January 1857).

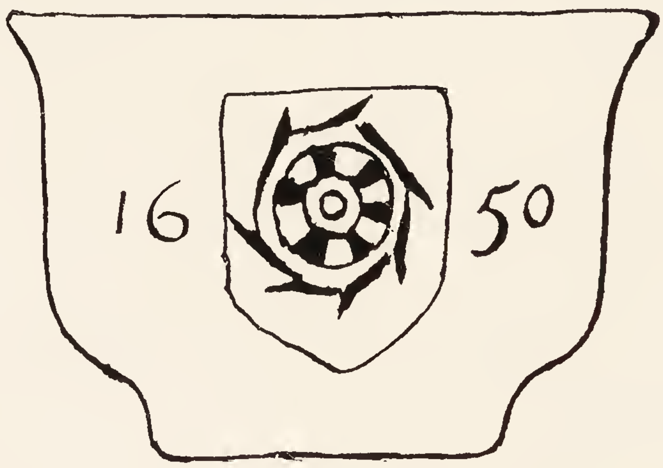
For Notes on Apothecaries and Materia Medica, see pages 328 *and* 472.

Downing Professors of Medicine

1.	Sir Busick Harwood (1745–1814).	1800
2.	Cornwallis Hewett (1787–1841).	1814
3.	William Webster Fisher (1797–1874).	1841
4.	Peter Wallwork Latham (1832–1923).	1874
5.	John Buckley Bradbury (1841–1930).	1894
	Discontinued.	1931

REGIUS PROFESSORS OF PHYSIC. 1540

1.	JOHN BLYTH (1503–57?) (King's).	1540
2.	JOHN HATCHER (1512–87) (St. John's).	1554
3.	HENRY WALKER (1503?–64) (Gonville).	1555
4.	THOMAS LORKIN (1528?–91) (Queens').	1564
5.	WILLIAM WARD (1534–1609) (King's).	1591
6.	WILLIAM BURTON (1560–1623) (King's).	1596
7.	JOHN GOSTLIN (1623–6) (Caius).	1623
8.	JOHN COLLINS (1572–1634) (St. John's).	1626
9.	RALPH WINTERTON (1600–36) (King's).	1635
10.	FRANCIS GLISSON (1597–1677) (Caius).	1636
11.	ROBERT BRADY (1626–1700) (Master of Caius).	1677
12.	CHRISTOPHER GREEN (1651–1741) (Caius).	1700
13.	RUSSELL PLUMPTRE (1709–93) (Queens').	1741
14.	Sir ISAAC PENNINGTON (1745–1817) (St. John's).	1793
15.	JOHN HAVILAND (1785–1851) (Caius).	1817
16.	HENRY JOHN HAYLES BOND (1801–83) (C.C.C.).	1851
17.	Sir GEORGE E. PAGET (1809–92) (Caius).	1872
18.	Sir TH. CLIFFORD ALLBUTT (1836–1925) (Caius).	1892
19.	Sir HUMPHRY DAVY ROLLESTON (1862–).	1925
20.	WALTER LANGDON-BROWN (Corpus).	1932
21.	JOHN ALFRED RYLE	1935



Drug pot with Arms of St. Catharine's Hall. *Birmingham Museum.*

X

ANATOMY

Anatomy in the thirteenth century is well illustrated by the pictures in MS. Caius 190.

In 1543 the entire science of Anatomy was revolutionized by the work and teaching which was given to the world by VESALIUS in his immortal work *De Fabrica Humani Corporis*. By this he convinced scholars that the old book-learning was leading to grave error, but that it was possible by patient observation and dissection to discover the truth. Following in his footsteps Fallopius, Eustachius, Variolus, and Servetus all made names for themselves, and the School of Anatomy at Padua became celebrated throughout the civilized world. Among those who came under the personal influence of Vesalius at that University was a native of Norwich, JOHN CAIUS: it is said that both lodged in the same house. On returning to England in 1541 Caius lectured on the new anatomy both in London and in Cambridge. Twelve years later he arranged that there should be a dissection every year at his new-founded college of Gonville and Caius. Moreover, he ordained that the bodies dissected should be treated with respect and be solemnly buried by the college with all the reverence due to the corpses of worthy persons. A few years later the *Anatomy*, published by Geminus, was revised in 1559 by RICHARD EDEN (1521?–76) of Queens' College.

From 1505 onwards the University had issued licences in Surgery and had enjoyed a good reputation for the standard of its teaching.

By the Edwardian Statutes of 1556 every student of medicine and surgery must have studied medicine for six years, have been present at two courses of dissection (*duas anatomias*) and maintain a thesis (*bis disputet, atque semel respondeat*) before he became a Bachelor. The surgical

student must have himself performed two courses of dissection and show that he had done at least *tres curationes* before he could be granted a licence in surgery. The Elizabethan Statutes also made it clear that whereas the medical student had to witness the dissections, the surgical student had to perform them himself.[1]

The form of petition ran:

> Supplicat Reverendis vestris, A.B., ut studium decem annorum in chirurgiâ cum approbatione peritissimorum in eâdem sufficiat ei ad practicandum in eâdem facultate, ita tamen ut ejus cognitio prius examinetur et approbetur a Regio in medicinâ professore (Gunning, *Customs*, &c.).

Two bodies for dissection were allowed to medical students of Caius College by Queen Elizabeth (*Hist. MSS. Commission Report*, II, p. 118).

The London Company of Barber Surgeons were so impressed by the quality of the Cambridge teaching in 1566 that they gave one of their more promising students an exhibition tenable at Magdalene College to complete his studies of medicine and surgery, on the condition that afterwards he should return to London and act as tutor to students at the Barbers' Hall. Similarly, if a Cambridge man desired to practise surgery in London he would have had to be licensed as a 'Foreign Brother'.

From 1570 to 1590 thirty-two persons took the M.B. or M.D., twenty-six the licence for medicine, and two for surgery only.

Of the students who were attracted to Caius College was William Harvey in 1594, and, as it was usual for Englishmen of this period to go abroad to receive their surgical teaching at some foreign University, such as Bologna, Pisa, Padua, Paris, Basel, or Montpellier, Harvey chose Padua. There he studied under Fabricius, and soon put the new anatomical knowledge to the test of his doctrine of the Circulation of the Blood.

It was in the seventeenth century that the foundations of sound anatomical and physiological knowledge were being laid. The discoveries of the circulation of the blood, of the function of lymphatics, of the true course of the

[1] A. Macalister, *History of Study of Anatomy in Cambridge*.

PROFESSOR FRANCIS GLISSON, M.D., F.R.S., P.R.C.P.

By courtesy of the Cambridge University Press

nerves and the structure of the brain, the purpose of respiration, and the minute structure of tissues as revealed by the compound microscope all stimulated the intensive study of anatomy and medicine at the Universities as never before.

Three Cambridge men were appointed lecturers on anatomy to the students under the Barber-Surgeon Company. One of them, ALEX. READ, had taken an M.D. at Oxford in 1620 and had incorporated at Cambridge in 1624. He died in 1641. The style of his instruction is shown by his '*Manual of the anatomy or dissection of the body of man, containing the enumeration and description of the parts of the same which usually are showed in the public anatomical exercises* by ALEXANDER READ M.D. Fellow of the Physicians' College and [Foreign] brother of the Worshipful Company of Barber Surgeons. A duodecimo of 446 pages printed in London 1638'.

The descriptions in this students' handbook show a great advance both in matter and method. The origin, insertion, and action of each muscle is briefly stated, and the difference noted between the contraction of a muscle in movement and that of a muscle kept in the same posture (*motus tonicus*). Read still regarded the contraction to be effected by the tendinous parts of the muscle. 'The brain', he notes, 'receives the charge from the soul, the nerve carrieth it to the muscle, and the muscle doth perform the act by the influence of the nerve as the loadstone draweth iron.' His account of the circulation is correctly taken from Harvey's new book.

FRANCIS GLISSON was born in 1597 at Rampisham in Dorset, went up to Caius as a scholar in 1617, becoming a Fellow in 1624 and Greek Lecturer in 1625. He is remembered for his work on the Nervous System (Whewell, *Hist. Inductive Science*, iii. 427–8). He succeeded to the Regius Professorship in 1636, and continued to occupy that chair for 41 years, during which period, *omnium anatomicorum exactissimus* as he was termed, he published his *Anatomy of the Liver* in 1654, gave the first clear account of Rickets in 1658, and by his experiment on muscular contraction showed that there is no increase in bulk when muscles contract in length. Living matter he defined by

its property of reaction to stimuli. In his work on the liver he describes the fibrous sheath, afterwards known as 'Glisson's Capsule'. 'I was the first', he wrote, 'to discover it, which I did twelve years ago, when, at the mandate of the College of Physicians in London, I delivered a course of public lectures.' Malpighi's work on the liver was based on Glisson's, but naturally went further, for he did not publish until 1666.

And finally in the year of his death (1677) appeared his last work on the anatomy of the stomach and intestines.

At Cambridge, as Dr. Parker has put it, 'The work of Caius, the compulsory dissections by students, and the demonstrations by the Regius Professor bore fruit in a brilliant body of writers', chief among whom, next to HARVEY and GLISSON, were:

BULLEINE.
HELKIAH CROOKE, St. John's, M.D., Leyden.
The TWO DRAKES, Pembroke, Roga. Leyden, 1639.
Sir GEORGE ENT, Sidney, M.D., Padua, 1636.
TH. WINSTON (1575–1655), Clare, 'Anat. Lectures'.
WM. BRIGGS, C.C.C., M.D. 1677, Oculist.
GEORGE JOLIFFE.
CLOPTON HAVERS, St. Cats., M.D., Utrecht, 1685.
TH. WHARTON (1614–73), Pembroke, M.D., Oxford.
W. CROON (embryologist), Emman., M.D., 1663.
NEEDHAM.
MARTIN LISTER.
ROBT. BRADY, Reg. Prof., 1677–1700.
EDWARD TYSON.

By a grace on November 27, 1646, two dissections were required from candidates for the degree of M.B., and three dissections for the degree of M.D. In 1651 'vividissections of dogs and such-like creatures' were popular.

Sir CHARLES SCARBOROUGH was the first to introduce Geometrical and Mechanical Speculations into Anatomy, being admirably well skilled in the Mathematics. When he was ejected from his fellowship at Caius he returned to Oxford and was created M.D. in 1646. He assisted Harvey to compile the *De Generatione animalium*.

Another notability was Sir THOMAS MILLINGTON (1628–1704), who had the advantage of belonging to both univer-

sities, for from Westminster school he came up in 1646 as a Scholar of Trinity, but in 1649 became a fellow of All Souls at Oxford. He published an Anatomy, and by his great skill as a physician raised a fortune, said to have amounted to over £60,000.

Two extraordinary cases of longevity are recorded. The Parish Register of St. Edward's contains the following notes:

1650 Elinor Gaskin said
She lived four-score years a maid,
And twenty and two years a married wife,
And ten years a widow, and then she left this life.

This was Elinor Bowman, commonly called the widow Bowman, who died August 17th, and was buried decently in St. Edward's Church-yard Aug. 18; her age 112 years.

In 1682 Dr. Gale informed the Royal Society that he knew a man at Coton who was then 120 years of age. When he was about 100 he had new hair and a new set of teeth. (*Birch*, iv. 165.)

The Eighteenth Century

It is interesting to note that about 1705, when he took the degree of M.D. at Cambridge, James Keill was reading anatomical lectures at both Oxford and Cambridge.

Between 1703 and 1706 William Stukeley gives us an excellent account of the activities of the medical student of his day, and of how they lost no opportunity for dissection.

Early in 1706 he records: 'At that time I sett myself to work in dissecting Dogs, & Herons, & all sorts of Animals that came in my way. We had an old Cat in the house, which had been a great favorite of my Fathers & the whole Familys, & by my Mothers leave I rid her of the infirmitys of age, & made a handsom sceleton of her bones, which I carryd to Cambridge with me the next Journey thither, & after I had taken my Degree & was leaving the University, I buryed her in a high walk by the side of the Lane leading from the Spittle house Conduit & the bridge in the road to Gogmagog hills, where I used frequently to walk. I likewise sceletonised several different sorts of birds, . . .

'At this time my tutor gave me a room in the College to dissect in, & practise Chymical Experiments, which had a very strange appearance with my Furniture in it, the wall was generally hung with Guts, stomachs, bladders, preparations of parts & drawings. . . . I then tryd a good experiment of blowing up the lungs thro a heated gun barrel for a day together, a pair of bellows being tyd to the wind pipe, & a pan of charcoal under the barrel, so that the lungs being thro'ly dry I pourd into them melted lead which filld up all their ramifications like the branches of a tree, then rotting the substance of them with water I had the finest animal plant that ever was seen which was mightily admired,[1] but I pulld it all to bits to give away little portions of it among my acquaintance.

'Here I & my Associats often dind upon the same table as our dogs lay upon. . . .

'When I came back to Cambridg [in 1707] I found Mr. Rolf dissecting there, & he was declard Professor of Anatomy in the University [by a grace passed on June 11].

'I prescribed often to one Smith, who was our Joyner, & the Fellow in gratitude promised me his body to dissect when he dyd, which happening next Spring when I was out of College, he expressed much concern that I could not have the benefit of his Promise.'

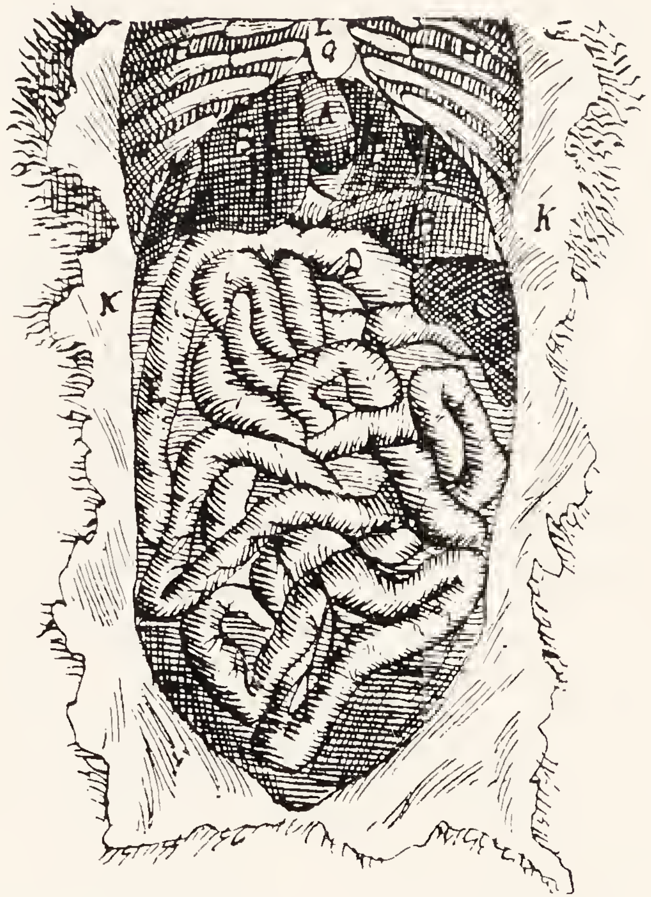
'We took up old Hoyes that hangd himself & was buryed in the highway, & dissected him, & afterwards made a sceleton of his bones, & put them into a fine Glass case with an inscription in Latin. . . .

'In December 1708 I went again to College, where I prepard myself for taking my Degree. I enter'd then into Fellows Commons. My Questions were in *Catamenia pendent a plethora*, upon which I made a Thesis when I kept my Act, Monday 24 Jan. 1708–9. Mr. Danny was my Far as we call it, and opend the Dispute with a jocular speech, according to custom, wherein he expatiated on my dissecting the Old Man of Holbech. Mr. Waller, another Fellow of our College, was my Prompter as the Method is, he being devoted to Physic.

'The exercise being over I kept my Feast where the

1 The method had been suggested to Stukeley by his friend Hales.

A Draught
of the Situation of the Contents of
the Abdomen, as appearing
when first opened.



A. The Gall bladder.
B. The Liver.
C. The Spleen.
D. The Stomach.
E. The Duodenum.
F. The Pylorus.
G. The Cartil. Ensiform.
H. The Thorax.
K. The Skin taken off.
L. Part of the Sternum.

made at CCCC. 1706.

Corpora binarum sic concrevere sororum,
Non nisi Divina dissocianda manu.
Seonija Patria est, Comoræ conterminus Arci,
Quæ nunquam Lunæ paruit Imperio.
Amplexa est Helenam Partu, Lucina priorem.
Horis deinde tribus nata Iuditha fuit.
Exitus Urinae patet unicus, Unicus alvo.
Observant numerum Cætera Membra suum.
Misit ad ignotos, tenuis Fortuna Parentum;
Ne pereat tantæ Fama stupenda rei.

I saw these children alive.
1707.

ILLUSTRATIONS FROM STUKELEY'S DIARY IN THE BODLEIAN LIBRARY

Professor Dr. Green, & his namesake the Mr of our College favord me with their company. . . .'

(Stukeley, *Family Memoirs, Surtees Soc.* 1882.)

Stukeley eventually became a Fellow of the Royal College of Physicians and delivered the Goulstonian Lectures [on the Spleen]. Later he gave up medicine and took Holy Orders.

The *Anthropologia Nova*, or a new System of Anatomy by James Drake, M.D. of Caius 1694, who had already written on respiration, was posthumously published in 1707.

Events which occurred in connexion with the Anatomy Act began to cause trouble. It was one thing to enact that dissections are necessary; but it is quite another matter to procure subjects.

In 1723 Parliament rejected an application for corpses of the felons of Cambridgeshire and Huntingdon for dissection by the medical faculty. In 1728 John Morgan's[1] (Trinity) Anatomy lectures were attended by John Byrom, Trinity 1708–63, and in 1730 he was known to have obtained a human subject on which to lecture. But in 1732 he evidently went too far, with the result that there was a riot. A body had been taken out of the churchyard of a neighbouring village to be dissected, and being stated to have been carried into Emmanuel College, Mr. Pern, J.P., granted his warrant to search the college for it: the constables broke into the College, but did not find the body.

The practice of body-snatching had become the cause of so many disturbances that the Senate passed a grace on May 9 forbidding it.

'*Cum* sepultorum cadavera e coemeteriis saepius furtim surrepta fuerint ad gravem plurimorum offensionem, *Placeat vobis* ut quisquis in posterum e coemeterio cadaver aliquod surripuerit vel ita surreptum celaverit infra limites academiae postquam legitime convictus fuerit coram procancellario si scholaris sit nondum graduatus suspendatur a gradu capessendo per biennium ultra consuetum tempus si vero sit graduatus gradu suo privetur sin scholarium

[1] John Morgan (1702), Trinity, Professor of Anatomy 1728–34.

gaudeat privilegio in perpetuum privilegium suum amittat.' (*Stat. Acad. Cantab.*, p. 417.)

In those early days the stipend of the Anatomist was hardly commensurate with the risks which he ran. For instance, when on March 25, 1736 the University petitioned against a bill to restrain the disposition of lands, it was pointed out that the Professor of Anatomy had no endowment at all!

Still, there were always candidates for the chair. At the contested election for the Professorship of Anatomy on Dec. 11, 1746, three candidates, received votes:

Dr. William Gibson of Jesus College got	55	votes
Samuel Hutchinson, M.A., fellow of St. John	43	,,
John Scotman, M.A., fellow of Caius	42	,,

[Mr. Hubbard's book (MS. Cole, li. 114).]

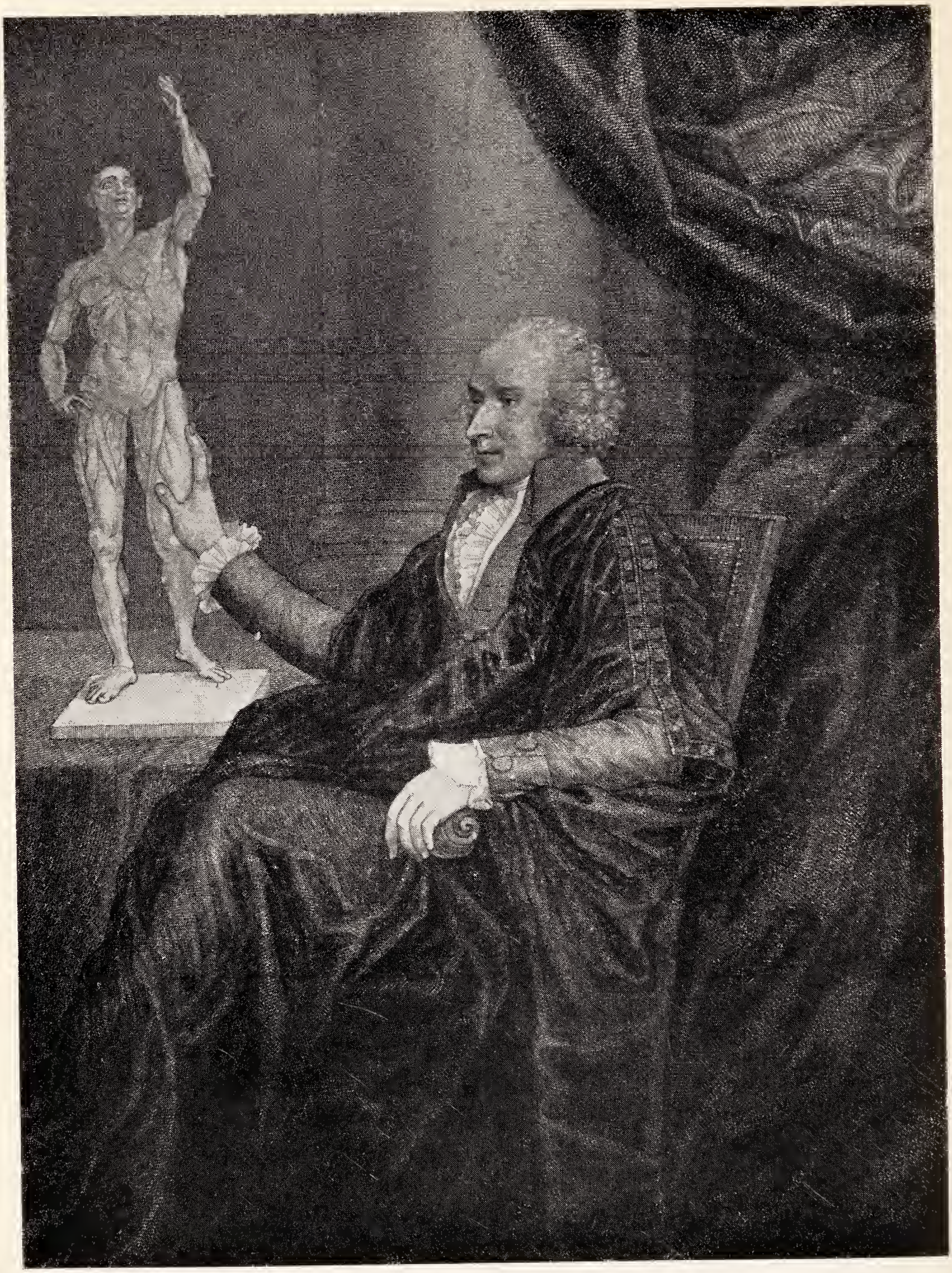
Gibson held the chair until his death in 1753.

Francis Sandys, teacher of Anatomy at Cambridge (M.D. 1739) is mentioned as discoverer of the *Membrana pupillaris*. His anatomy preparations were acquired by W. Hunter. (Simmons's *Life of Dr. W. Hunter.*)

Dissections were occasionally made in the privacy of College-rooms. For instance, in 1750 F. Coventry of Magdalene described the preparations made for such an event.[1] And about 1765 Professor Watson procured a corpse from London and dissected it in his laboratory, with the help of E. Waring (Magd.) and W. Preston (Trinity). 'The remains were not properly buried, and their discovery would have led to the stoning of the operators, had they been known' (Wordsworth). Both Watson and Preston became Bishops.

C. Collignon, Trinity, M.B. 1749, sixth Professor of Anatomy (1753–85) published a *Compendium Anatomico-Medicum* in 1756, of the lectures which he delivered in March. Of his other works, *An Enquiry into the Structure of the Human Body* was issued in 1764, 1771, 1795–6; and *Medical and Moral Tracts* in 1769. He deputized as Regius Professor of Physic for Plumtre in 1779, and became Downing Professor of Medicine 1783–5, as well as professor

[1] Coventry, *Pompey the Little* II. xi.



PROFESSOR SIR BUSICK HARWOOD, M.D., F.R.S.

By courtesy of the Cambridge University Press

of Anatomy. One of his anatomy courses began on 16 February, 1779 at 3 p.m.

Jacob Butler, owner of Barnwell, died aged 84 on May 28, 1765. Medical students must often have delighted in his demonstrations. He was 6 ft. 4 in. high, and usually invited the giants and dwarfs who came for exhibition at Sturbridge fair to dine with him.

Another *rara avis* was Sir Soulden Lawrence, Law fellow of St. John's, B.A. 1771, the son of the eminent Reader of Anatomy at Oxford.

Busick Harwood, 7th Professor of Anatomy, 1785–1814, was a native of Newmarket who served abroad as a surgeon in India for several years, where according to his own story he performed successful and highly paid operations on natives. On returning to Cambridge he became a fellow-commoner of Christ's. His uproarious behaviour at the annual feast made him popular, and he entertained largely. In 1785 he took his M.B. and succeeded Dr. Collignon as Professor of Anatomy. About 1790 he migrated to Emmanuel, being attracted by rooms with an extensive garden.

'He purchased a house adjoining his garden, in which he placed his man-servant and wife, where his dinners were usually dressed. During term-time covers were daily laid for half-a-dozen, and the professor in the course of his morning walk always contrived to pick up the requisite number of guests. A plain dinner was neatly served up at two o'clock; and as his lectures began at four, there was no great consumption of wine, and the guests, with scarcely an exception, accompanied him to lectures. He was at that time lecturing on comparative anatomy; and it was no unusual thing to see the turbot on which Mr. Orange [his demonstrator in anatomy] had exercised his skill one day, carved by the professor on the following.' Gunning, *Reminiscences*.

He married the only daughter of Sir John Peschell of Oxfordshire.

His rooms were hung with portraits of his friends by Harding. He once wrote a ridiculous challenge to Sir Isaac Pennington to a duel.

His course included '*Comparative Anatomy* and *Physio-*

logy; in which the structure and economy of *Quadrupeds, Birds, Fishes'* [which, according to Gunning, occasionally reappeared at his hospitable dinner-table] 'and *Amphibia* are investigated; the several organs which constitute the Animals of the different classes compared with each other, and with those of the Human Body; the most striking analogies pointed out, and remarkable varieties accounted for, from . . . . the Animals belonging to each class'.[1]

Pathological remarks on the diseases to which man and other Animals are liable are introduced, with observations on the nature and effects of the Medicines usually employed for their removal. The *Anatomia* Medico-Forensis, together with the effects of various Poisons, and also of suspended animation, and the recovery of drowned persons, occupy a share of these Lectures. At the commencement of the course, the Blood of various Animals is compared with that of the Human Species: the doctrine of *Transfusion* is investigated: its probable advantages and defects inquired into, and the practice illustrated by an actual experiment.

B. Harwood, *Synopsis of a Course of Lectures on the Philosophy of Natural History* 4to Camb. 1812. His anatomical museum was purchased by the University for £360; but in 1828 the wax models were suffering by being kept in the old chemical room.

A taller man than Jacob Butler was Thomas Bell, a native of Cambridge, who was exhibited at the Hog in the Pound, Oxford Street, London as 'The Cambridge Giant' in May 1813. He was 36 years of age, 7 feet 2 inches high; his hands 11 inches, his middle fingers 6 inches in length. He considered himself as double jointed. A portrait of T. B. appeared in Kirby's *Wonderful and Eccentric Museum*.

At the election for a Professor of Anatomy to succeed Sir Busick Harwood in 1814, 345 votes were cast. John Haviland, M.A. and Licentiate in Physick, fellow of St. John's College, received 150 votes; William Clark of Trinity, 135 votes (elected in 1817 to Professorship); John Thomas Woodhouse, M.D., Fellow of Caius College, 60.

The provision of bodies for dissection gave trouble.

In 1834 on the evening of December 2nd a very violent

[1] T. Martyn, Professor of Botany, had published *Elements of Natural History*, vol. 1, Part 1, *Mammalia*. 1775.

attack was made by an excited mob on the Anatomical Theatre. The Riot Act had to be read before peace was restored, but not before considerable damage had been done. The outbreak was occasioned by the body of an aged pauper of Trinity parish, named Porter, having been irregularly given up for dissection. The body was restored for interment on the following day.

The erection of new Anatomy Schools so depleted the funds of the University that a syndicate of inquiry was appointed in 1843.

In June 1844 Frederick Augustus, King of Saxony, was being shown round Cambridge by C. G. Carus, and Dr. Paget and Professor Clark were invited to meet him.

'We next examined the botanical garden, which appears as indifferently supplied as the museum of comparative and pathological anatomy. As however I happened to have time to remain here a little longer than in other departments, I discovered one among the pathological preparations, whose importance had hitherto escaped Dr. Clark himself. It was a case of *Graviditas ut erat uvaria*, of whose remarkable conditions, and transition to *Graviditas interstitialis*, English physicians appear hitherto to have little or no knowledge. This collection also contains some very interesting skulls of savages, of which the curator presented me with one belonging to a New Zealander, which as a historical vade mecum was henceforth to be my carriage companion during the rest of our excursions.'[1]

On March 6, 1846, the American dwarf, Tom Thumb, was exhibited at the Town Hall. Serious disturbances ensued.

MACALISTER succeeded Prof. Humphry in 1883. He came from Dublin with a wonderful reputation of having navigated the aorta of a whale and of adventurous travels into the interiors of seven elephants. At Cambridge his versatility and the accuracy of his knowledge whether of Church History or Animal Morphology was phenomenal. An article in the *Cambridge Review* caused him to change the hour of his Anatomy lectures from the luncheon hour of 1 to 12.

[1] *The King of Saxony's Journey in the year 1844 by C. G. Carus.* Transl. by S. C. Davidson 1846.

Professorship of Anatomy, 1707

1.	George Rolfe.	1707
2.	John Morgan.	1728
3.	George Cuthbert.	1734
4.	Robert Banks (1702–46).	1735
5.	William Gibson (1714–53).	1746
6.	Charles Collignon (1725–85).	1753
7.	Sir Busick Harwood (1745–1814)	1785
8.	John Haviland (1785–1851).	1814
9.	William Clark, Trinity (1788–1869).	1817
10.	Sir George Murray Humphry, Downing (1820–96).	1866
11.	Alexander Macalister, St John's (1844–1919)	1883
12.	John Thomas Wilson.	1920
13.	Henry Albert Harris (London).	1934

Professorship of Surgery, 1883

1.	Sir George Murray Humphry, King's (1820–96).	1883
	[Suspended, 1896–1903] Joseph Griffiths (King's) being appointed 'Reader'.	1898
2.	Frederick Howard Marsh, Downing (1839–1915).	1903

Lecturer in Surgery

1.	G. E. Wherry (1852–1928), Downing.	1883–1911

XI

PHYSIOLOGY

The Physiology of the Greeks comprised the study of all natural phenomena, and in this wide sense persisted until as late as the 17th century. But in the 11th century the application of the word became strangely restricted, when Theobald, abbot of Monte Cassino, composed a collection of stories about animals with morals, which under the title *Physiologus* became a best seller in the Middle Ages. It was devoid of scientific value.

A good two centuries elapsed between the first usage of the term Physiology in its modern sense of the study of functions of living matter by Jean Fernel in 1554, and its final establishment as a branch of biological science by Albrecht von Haller by the publication of his *Elementa Physiologiae Corporis Humani* in 1757 onwards. In this modern development few Universities have played a more honourable part than Cambridge.

That not one of the forty physiologists who are distinguished by being included in Sir Michael Foster's list of honour of 'chief' among the pioneers, was born either at Oxford or Cambridge, may safely be attributed to the prevailing celibacy of the early academic residents at those places. Pre-eminent among Cambridge men were Harvey, Glisson, and Hales. Oxford can boast T. Willis, Boyle, Hooke, Mayow, and Lower, while Wharton, Black, and Priestley came from the north.

HARVEY 'was not tall, but of the lowest stature, round faced, olivaster (like wainscott) complexion; little eie, round, very black, full of spirit; his haire was black as a raven, but quite white twenty yeares before he dyed'.

Such was the description of John Aubrey, who knew him well when he was working at Trinity College in Oxford, for he was very communicative and willing to instruct any that were modest and respectful. When Aubrey was planning a tour in Italy, Harvey dictated to him what to see, what company to keep, what books to read, and how to manage his studies.

But Harvey's great work was done long before Aubrey became acquainted with him. Already in 1616 he had been puzzling over the difficulties and discrepancies presented by the ancient conceptions of nature. Born and bred as he was in the days before serious doubts had been cast upon the truth of Aristotelian and Galenic doctrine, his work was the most revolutionary that the history of biology has to show. Like the epoch-founding works of Galileo and of Gilbert of Colchester, Harvey's reasoned presentation of his discoveries, based on his own observations and experiments devised and tried out by his own hand, will always be regarded as fundamental for Neosophy.

The chief works of Francis Glisson of Caius on *rickets* and on the *liver* have been mentioned elsewhere. As a Physiologist he is remembered for his *Tractatus de natura substantiae energetica* 1672, wherein he endeavoured to show that all phenomena exhibited by life as well as by inanimate things are the successive developments of the one fundamental energy of Nature.

In his work on the Liver he drew attention to the intermittent action of the gall-bladder and biliary duct, showing that they discharge bile at certain times only, and that this discharge is the consequence of a greater excretion due to some irritation. Now an organ cannot be irritated unless it possesses the power of being irritated, and for this power he proposed the name of *Irritability*. Later, in his work on the stomach, *De Ventriculo*, written in 1662, though not published before 1677, he recurs to the same phenomenon. But little attention was paid to this idea by others until Haller showed its importance. Sir Michael Foster points out that it is worthy of note that from the very first Glisson distinguished the various ways in which irritability may be manifested and the various agents by which it may be called forth.

Another great contribution to physiology due to Glisson was the demonstration that when a muscle contracts it does not increase in bulk. It had previously been believed that muscular contraction was due to some 'explosion and inflation of spirits' in the muscle.

Glisson's Experiment

'Take an oblong glass tube of suitable capacity and shape. Fit into the top of its side near its mouth another small tube like a funnel. Let a strong muscular man insert into the larger tube the whole of his bared arm, and secure the mouth of the tube all round to the humerus with bandages so that no water can escape from the tube. Then pour water through the funnel until the whole of the larger tube is completely filled, and some water rises up into the funnel. This being done, now tell the man alternately to contract powerfully and to relax the muscles of his arm. It will be seen that when the muscles are contracted the water in the tube of the funnel sinks, rising again when relaxation takes place. From which it is clear that muscles are not inflated or swollen at the time that they are contracting, but on the contrary are lessened, shrunk, and subsided. . . . From this therefore we may infer that the fibres are shortened by an intrinsic vital movement and have no need of any abundant afflux of spirits, either animal or vital, by which they are inflated, and being so shortened carry out the movements ordered by the brain.'

But this again faded into oblivion until the matter was taken up by Haller in the following century.

Among the minor lights must be mentioned Dr. William Holder of Pembroke Hall who married the sister of Christopher Wren and was inducted rector of Bletchington in Oxfordshire in 1642, where he obtained the affection of all by his hospitality and learning. It was there, too, that he gave Wren his first instruction in geometry and arithmetic. When at Bletchington in 1659 he obtained a great name for his most wonderful art in making the deaf and dumb to speak. He succeeded with the son of Colonel Popham, and later in the case of a young man, one Whaley, who had lost his speech when he was 5 years of age. *Philosophical Transactions*, July 1670.

For his discourse on the *Elements of Speech* 'he was beholding to no author; did only consult with nature', and when Dr. J. Wallis 'unjustly arrogated the glory of teaching the young gentleman to speake in the Philosophical Transactions', Dr. Holder was 'occasioned to write against him'.

A proper account of the structure of bone was first written by Clopton Havers (? 1650–60–1702), who had been for a time at St. Catharine's Hall, but who took his M.D. at Utrecht in 1685. He wrote the *Osteologia Nova, or some new Observations of the Bones and the parts belonging to them.* Every medical student is now familiar with his name as applied to the Haversian Canals, characteristic of the structure of bone.

Physiological studies occasionally aroused animosity in Cambridge, as for instance in 1688 when Clement Scott, fellow of C.C.C., had his rooms looted by a mob, who finding a copy of Boyle's *Experiments on Blood,* some cried out, 'See what a bloody-minded dog he is, his books are full of nothing but blood.'

A paper on *Some influence of respiration on the motion of the heart hitherto unobserved* was contributed to the Royal Society about 1690 by James Drake, M.D. of Caius College, a native of Cambridge. He died on 2 March 1706–7.

A star of the first magnitude was Stephen Hales, 1677–1761. Born at Bekesbourne in Kent in 1677, he came up to Cambridge as a pensioner of Corpus in 1696, and was elected a fellow in 1703. In 1709 he was appointed minister of Teddington, where without in any way neglecting the spiritual welfare of his charges, he applied scientific knowledge to the practical solution of a variety of most important problems in physiology, botany, and hygiene.

Sir Francis Darwin speaks in the highest terms of the value of Hales's work. 'In first opening the way to a correct appreciation of blood-pressure Hales's work may rank second in importance to Harvey's in founding the modern science of physiology.' He was the greatest physiologist of his century.

He invented the manometer, with the aid of which he was able to make quantitative estimates of blood-pressure

and measure the velocity of the blood-current. He knew how to keep blood from clotting with saline solutions.

He studied the shape and form of muscles in contraction and at rest. Cf. the 2nd part of Hales's *Statical Essays*, entitled *Haema-dynamics*, 1733.

The Circulation of the Blood

The important contributions made by Hales to our knowledge of the physiology of the circulation seem to have been begun at Cambridge in 1708, but repeated and finished at Teddington soon after he had gone to live there as 'Perpetual Curate' of that parish in August 1709. During the previous six years he had been sufficiently associated with Stukeley and his botanical and astronomical studies to realize the importance of the working of the heart and blood-flow, while his own acquaintance with physics and mechanics helped him to his experimental method for its elucidation.

Moreover, he desired to institute a comparison between the energy required to force blood along an artery and the energy expended in forcing sap up the stem of a tree during the 'bleeding season' in spring (see p. 385).

Borelli had *calculated* the blood-pressure from measurements of the capacity of the heart and the volume of the vessels, but they had led him to the absurd conclusion that the force of each heart beat was 135,000 pounds. Lower had extended Harvey's knowledge of the heart by describing its muscular structure and nerve-supply, and had shown that a heart separate from the body would continue to beat. He had also calculated the volume of blood pumped at each contraction of the ventricles and the velocity of the blood-flow in the arteries. But as the source of muscular energy was unknown, the lateral swelling of the muscles was regarded as being due to the blood in the nutrient vessels being forced into and so dilating the muscle fibres.

Hales was not satisfied with this explanation. It occurred to him 'that by fixing tubes in the arteries of live animals, I might find pretty nearly, whether the blood, by its mere hydraulic energy, could have a sufficient force, by dilating the fibres of the acting muscles, and thereby shortening

their lengths, to produce the great effects of muscular motion. And hence it was, that I was insensibly led on from time to time into this large field of statical and other experiments'.

Hales's choice of an animal for his experiment was doubtless influenced by a desire to secure one in which hydraulic and hydrostatic phenomena might be on the largest scale. So finding that a horse and a mare were to be killed as unfit for service, he caused the mare to be tied down alive on her back. 'Having laid open the left crural artery about 3 inches from her belly, I inserted into it a brass pipe whose bore was $\frac{1}{6}$ of an inch in diameter; and to that by means of another brass pipe which was fitly adapted to it, I fixed a glass tube of nearly the same diameter, which was 9 feet in length: then untying the ligature on the artery, the blood rose in the tube 8 feet 3 inches perpendicular above the level of the left ventricle of the heart: but it did not attain to its full height at once.' Also it was observed to rise and fall at and after each pulse 2, 3, or 4 inches. *Haemastatics*, pp. 1–2.

After further confirmatory experiments, he endeavoured to determine the output of the heart per minute. This was done by injecting the interior of the left ventricle with melted wax at a pressure comparable to that normal in the great veins near the heart. One of the subjects selected was 'a very gentle cow which was not terrified or disturbed while its pulse was counted': others were sheep and dogs of various sizes. His results, summarized in a table, show that though the ventricular output at each beat is proportional to the size of the animal, the heart of a small animal, in consequence of its greater rapidity of action, throws out a weight of blood equal to the weight of its body in less time than a big one. *The output of the heart per minute is therefore relatively greater in small animals than in large.*

He then proceeded to determine the resistance offered to the circulation by the small arteries, capillaries, and veins in the following manner: The arterial blood-pressure in the carotid artery of a dog was measured. The animal was then killed and the volume of the left ventricle determined by the molten wax method. The two crural arteries were then ligatured, the descending thoracic aorta divided, the intes-

tines exposed, and slit open throughout their whole length opposite the line of mesenteric attachment. A glass tube was then tied into the peripheral end of the cut aorta, and the slit guts were perfused with warm water at a pressure equal to the normal arterial pressure. It was found that 342 cubic inches of water passed through the preparation in 6·6 minutes.

The mesenteric arteries were then cut close to the intestines and the 342 cubic inches of water passed through in 2·3 minutes. When the crural arteries were severed and other arties cut close to their origins from the aorta the same volume of water passed in 0·4 minute. 'Thus the velocity of the water is retarded in passing thro' the several branchings of the arteries, notwithstanding the sum of the areas of their transverse section is considerably greater than that of the aorta. . . . The resistance in the capillary passage may be greatly varied, either by the different degrees of viscidity or fluidity of the blood, or by the several degrees of constriction or relaxation of those fine vessels.'

The causes which influenced the constriction was a subject for further research. He found that hot water increased the rate of flow; but cold water, decoctions of Peruvian bark, chamomel flowers, and cinnamon all decreased the rate of flow, as also did alcohol.

The physics of the lesser circulation through the lungs next engaged his attention. And here, too, he obtained measures which are surprising when we consider the time at which they were made. Having successfully calculated that the velocity of the blood in the lungs must be much greater than in the body, he actually succeeded in observing the speed of blood corpuscles in the abdominal muscles and lungs of a frog, estimating that they moved five times as fast in the lungs as in the muscles.

Other important steps towards the establishment of the young science of physiology on a sound basis were described in his *Haemastatics*. He showed that blood-pressure is quite insufficient to account for muscular action. 'This wonderful and inexplicable mystery of nature must therefore be owing to some more vigorous active energy, whose force is regulated by the nerves.'

'He studied the effects of progressive dilution of the blood with water, and produced ascites and anasarca by intravenous injection. He prevented the blood from clotting by adding nitre. He performed experiments on the effects of the respiratory movements on the intrapleural pressure. He measured the force required to burst the arteries, veins, and guts and the tensile strength of bones, ligaments, and tendons. He observed the contraction of individual muscle fibres in the frog.

'It is not easy to get a sight of this most agreeable scene, because that on the action of the muscle, the object is apt to get out of the focus of the microscope; but those who are expert in the use of those glasses may readily move them accordingly.' *Haemastatics*, p. 61.

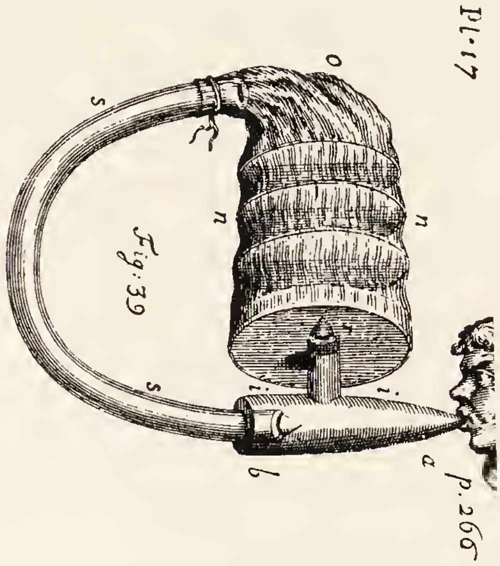
Respiration

The classic experiments on respiration and combustion which had been performed by Mayow in Oxford were repeated by Stephen Hales, who first assured himself of the truth of the fact that a candle burning under a closed vessel over water does absorb about $\frac{1}{11}^{\text{th}}$ of the air, and goes out in a minute. Whereas a half-grown *rat* under the same circumstances absorbed $\frac{1}{13}^{\text{th}}$ of the air, and lived 10 hours; and a kitten absorbed $\frac{1}{30}$ part of the air and lived for one hour. *Vegetable Statics*, p. 237.

He then tried a re-breathing experiment upon himself.

'I made a bladder very supple by wetting of it, and then cut off so much of the neck as would make a hole wide enough for the biggest end of a large fosset to enter, to which the bladder was bound fast. The bladder and fosset contained 74 cubic inches. Having blown up the bladder I put the small end of the fosset into my mouth; and at the same time pinched my nostrils close, that no air might pass that way, so that I could only breathe to and fro the air contained in the bladder. In less than half a minute I found a considerable difficulty in breathing, and was forced after that to fetch my breath very fast; and at the end of the minute, the suffocating uneasiness was so great, that I was forced to take away the bladder from my mouth. Towards the end of the minute the bladder was become so flaccid that I could not blow it above half full with the greatest expiration that I could make.' *Vegetable Statics*, p. 238.

To investigate the matter further he set up an apparatus, by which the inspired air and the expired air could be measured. On returning the expired air back to the vessel holding the inspired air, he found that $\frac{1}{136}^{\text{th}}$ part had disappeared. A breathing animal therefore absorbs air even as a growing plant does.



It has been suggested that Stephen Hales should be given the credit for the invention of the chemical respirator, but that surely must have been adopted by many men in their hour of need, even as the Arab in a desert storm will wrap his burnous round his head. Hales suggested that smelters of metals, plumbers, &c. might protect themselves from the noxious fumes by 'pretty broad mufflers, filled with two, four or more *diaphragms* of flannel or cloth dipped in a solution of *sal tartar* or *pot-ash* or sea-salt and then dried. The like mufflers might also be of service in many cases where persons may have urgent occasion to go for a short time into an infectious air: which mufflers might, by an easy contrivance, be so made as to drawn in breath thro' the *diaphragms*, and to breathe it out by another vent'. *Vegetable Statics*, p. 272.

May we not, therefore, at least claim for Hales an important discovery of the evidence for carbon dioxide?

It was natural that no advance in the theory of Respiration was possible before chemists were able to inform physiologists as to the nature of gases. Hales, for instance, lacked the most elementary knowledge of the subject. He calls all gases 'air', which varied its properties. Sometimes

it would be 'elastick with particles repelling one another', sometimes 'fixed', its particles being attracted to some other substance, e.g. sulphurous particles, sometimes it would be inflammable, sometimes not, sometimes respirable, sometimes bad to breathe. The progress of distinguishing different gases is shown in the following table:

Carbonic acid gas	first collected by Van Helmont in c.	1640.
,,	but more definitely known to Black in	1757.
Nitrogen	first observed by Rutherford in	1772.
Oxygen	prepared by Priestly in	1774.
,,	recognized by Lavoisier in	1775.
Hydrogen	first definitely understood by Cavendish in	1781.

In 1794 Lavoisier was executed!

CAVENDISH was the first to prove the relation between nitre and the chief constituent of atmospheric air, by showing that when electric sparks are discharged through air nitric acid is formed.

Ossification and Growth of bone

Hales's researches on plant-growth suggested that the growth of animals might be determined by similar factors.

To settle the point, he made an experiment that was repeated by John Hunter many years later.

'I took a half-grown *chick*, whose leg-bone was then 2 inches long; with a sharp-pointed iron, at half an inch distance, I pierced two small holes thro' the middle of the scaly covering of the leg and shin-bone; two months after I killed the *chick*, and upon laying the bone bare, I found on it obscure remains of the two marks I had made at the same distance of half an inch: so that that part of the bone had not at all distended lengthwise since the time that I marked it; notwithstanding the bone was in that time grown an inch more in length, which growth was mostly at the upper end of the bone, where a wonderful provision is made for its growth at the joining of its head to the shank called by anatomists *symphysis*.' *Vegetable Statics*, p. 339.

Transfusion

The timorousness of a would-be Transfusionist is illustrated by the case of Lady Northesk when attended by Dr. ERASMUS DARWIN.

He described his hesitation as follows:

'The construction of a proper machine is so nice an affair, the least failure in its power of acting so hazardous, the chance at last from the experiment, so precarious, that I do not choose to stake my reputation upon the risque. If she die, the world will say I killed Lady Northesk though the London and Bath physicians have pronounced her case hopeless, and sent her home to expire. They have given her a great deal too much medicine, I shall give her very little.' Seward's *Memoirs*.

According to Robert Whytt of Edinburgh Hales observed reflexes in spinal frogs and their abolition by destruction of the cord quite a quarter of a century before Whytt described reflex action in 1757.[1]

At least three physiological problems were investigated by Dr. W. HYDE WOLLASTON. He estimated that during the contraction of a muscle, the contractions are repeated at intervals of $\frac{1}{20}$th to $\frac{1}{30}$th of a second. *Croonian Lecture*, c. 1820.

Next he found that the hearing of many persons terminates at a note four or five octaves above the middle E of the pianoforte, while he could distinguish notes of the sixth octave. He connected with this observation a beautiful speculation as to the possibility of grasshoppers, crickets, and other emitters of shrill notes also being able to hear notes of higher pitch than can the human ear.

His paper on the *Semi-decussation of the optic nerves*, published in 1824, has a pathetic interest, because its author died of a cerebral tumour near the origin of the optic nerve which was the cause of one-sided blindness from which he suffered until his death in 1828.

The theory of colour vision was consolidated by Clerk Maxwell's experiments in confirmation of Young's physiological theory which reduced all colour sensations to three primary effects.

Modern physiology was first taught in England as a separate science by a specialist at University College in London by William Sharpey (1802–80), an Edinburgh

[1] Whytt, *Physiological Essays* 1755, p. 176.

student, who had succeeded Quain as Professor of Anatomy and Physiology. His strength lay in his gifts as an inspiring teacher and an encourager of research among others. Amongst his pupils were Burdon Sanderson and MICHAEL FOSTER, U.C.S. (1849–52), 1816–1907. In 1867 Wm. Sharpey invited Foster to inaugurate the teaching of practical physiology and histology at University College. In London he soon came under the influence of Huxley, whom, with Lankester (1847–1929) and William Rutherford (1839–99), he assisted with his first class of elementary biology in 1870 at S. Kensington.

In 1870 he was appointed Praelector at Trinity to the lasting benefit of Cambridge and of Cambridge science. His successor at University College was Sir John Burdon-Sanderson (1828–1905), who came to Oxford in 1882. As Praelector at Trinity it was Foster's duty to teach the undergraduates of the University as a whole. By a grace a room in the New Museums Building, then intended for a museum of philosophical instruments and now the Philosophical Library, was allotted for the physiological lectures, and in it was contrived a laboratory for physiology, elementary biology, and embryology. It was the first laboratory to be provided since the allocation of the room in Trinity to Stephen Hales c. 1708.

A better-equipped physiological department was built and occupied in 1879, enlarged in 1887, and again in 1890. A new building at a cost of £22,000 was given by the Drapers' Company of London and opened in 1914.

At the outset Foster set to work to frame courses of practical work in Physiology modelled on those which Huxley had inaugurated in London, or like those which Charles Yule, with scantier endowment, had started in the Daubeny Laboratory at Oxford. In Cambridge Foster soon found his reward in the enthusiasm and devotion of his pupils: Francis Maitland Balfour (1851–82), Walter H. Gaskell (1847–1914), A. Sheridan Lee (1853–1915), J. N. Langley, Newall Martin, Francis Darwin, C. S. Sherrington, George Adami, and others.

Then came his *Text-book of Physiology* (1876), followed some ten years later by the *Journal of Physiology* (1887), which did more to spread the good work and a knowledge

of physiological methods among English-speaking peoples than any other publication.

In 1883 a separate chair for Physiology was founded at Cambridge, with Michael Foster as the first Professor. For twenty-two years he acted as one of the biological secretaries of the Royal Society. He presided over the British Association Meeting at Dover in 1899; he was a member of numerous Royal Commissions.

History of Physiology appeared in 1901 and was reprinted in 1924.

Textbook of Physiology, 1 vol. in 1876; 7th edit. 1897 in several vols.

'He worked *for* rather than *at* physiology' (Gaskell).

J. N. LANGLEY, Sizar of St. John's 1871, succeeded Newell Martin as Foster's demonstrator in 1875, and helped him in writing *A Course of Practical Elementary Physiology and Histology* 1876. In 1877 he was elected to an open fellowship at Trinity. For 16 years he worked at secretory changes in glands, showing that zymogen granules stored in the cell during rest disappear during activity (v. Schäfer, *Text-book of Histology,* 1898), and then for 35 years at the autonomic nervous system, which had been begun by Gaskell, and in which Langley was assisted by HUGH K. ANDERSON (1865–1928), Master of Caius. He obtained the Royal Medal of the Royal Society in 1892.

GASKELL became acquainted with Michael Foster about 1870. 'He was born at Naples in 1847, and entered Trinity College in 1864. As a graduate he worked at Leipzig under Carl Ludwig on nervous control of the circulation in the voluntary muscles of the frog. His work falls mainly under three heads. He began his researches by studying the innervation of blood vessels in striated muscles, and was gradually carried on to the investigation of the small arteries of the heart with varying reactions of the blood. He found that small additions of alkali increased their tone, and small additions of acid decreased it, and he was one of the first to recognize that there is a chemical control in the organs and tissues as well as a nervous one. Later he turned his attention to the innervation of the heart and the cause of the heart beat. At that time it was held that the nerve cells present in the tissues of the heart

control its beat. But there is some evidence that the nerves were not the sole controlling cause, and in a series of masterly papers Gaskell expounded the view of the muscular origin of the beat, and showed how the beat is conducted in the four chambers of the heart. Recently great advances have been made in the application of physiological methods to the clinical examination of the heart, and this great help to suffering humanity is largely based upon Gaskell's work.

'His studies on nerves led him on to investigate the structure, origin and connexions of the sympathetic nervous system. He described the relations of these ganglia with the spinal cord, and gave an accurate interpretation of their mode of action. His last book is entitled *The Involuntary Nervous System.*'

Another important piece of work was to investigate the action of chloroform on the heart, under the auspices of the Nizam of Hyderabad's Commission to ascertain the causes of death under chloroform. With Dr. L. Shore of St. John's College, Gaskell found that chloroform had a direct weakening action upon the heart, and that therefore both the heart and lungs should be watched when anaesthetics are administered.

His third great work on the *Origin of Vertebrates*, 1908, being morphological rather than physiological, is more appropriately mentioned under the head of Zoology.

According to Gaskell's hypothesis, Vertebrates have been derived from some Crustacean or Arachnid-like ancestor, and in his search for the missing links he made a profound study of the structure and histology of *Limulus* on the one side of the gap, and of the larval Lamprey on the other. After years of patient work, he made a final pronouncement at the meeting of the British Association of 1896, but although all present were unanimous in praising the eloquence and the ingenuity of his argument, zoologists found themselves unable to accept it.

The works by which he is best known are:

Contraction of Cardiac Muscle, art. in Schäfer's *Physiology* 1900.

On Origin of Vertebrates 1889 and 1908.

Cause of death under Chloroform 1890.

Charles Smart Roy (1854–97), as George Henry Lewes Student, worked with Foster. Soon after his election into the Royal Society, he was appointed first Professor of Pathology at Cambridge. He devised the Roy's Frog cardiometer, and Roy's Renal Oncometer for studying variations in blood-flow through the kidney.

Among his pupils were J. G. Adami, W. Hunter, Alfred Karthack, Lorrain Smith, W. Westbrook, and Lewis Cobbett. With Adami he invented the Cardiac-plethysmograph and Cardio-myograph, both used in the course of his long researches on the mammalian heart.

The Capillary Electrometer made by Keith Lucas in 1910 was used by him for researches on the nervous impulse. Owing to its great rapidity this electrometer gave much more accurate records of the electric changes in nerve than the string electrometer or any other instrument that had been previously used for the purpose.

Biochemical Laboratory

Among the historic pieces of recent apparatus preserved in the new Biochemical Laboratory is:

The apparatus used by Walter Morley Fletcher in 1897 for measuring the carbon dioxide production of muscles *in vitro*.

The muscle was contained in a special vessel through which passed air previously freed from carbon dioxide by a potash tower. The current of air, drawn by an aspirator, after leaving the muscle-chamber, entered the apparatus at M and was switched through to the absorption-bulbs A or B by the taps N or O respectively. Entries P & Q were kept closed. The absorption-bulbs were filled with standard baryta through the burettes Y, Y, which connected with the atmosphere only through the potash trap V, and the baryta reservoir, W. Titration was carried out by means of the burettes X, X, which contained standard acid and were filled by compressed air from U. The use of two absorption-bulbs permitted continuous operation, titration of the carbonate in one accompanying absorption of carbon dioxide in the other. The resistance-bottles, Z, Z, allowed the gas stream to pass through an amount of

water equal to that of baryta usually used, thus avoiding stagnation and accumulation of carbon dioxide in the system. If the second switchboard, F, was adjusted, two muscle-chambers could be used instead of one, and G_1 & G_2 were part of the pressure circuit for driving the contents out of the reservoirs.

This was the apparatus by means of which Fletcher studied the carbon dioxide production of muscles in the presence or absence of oxygen, either stimulated or at rest. His work led to the foundation of modern muscle bio-chemistry in the classical investigations of Fletcher and Hopkins on lactic acid formation in muscle.

(W. M. Fletcher, *Journ. Physiol.* 1898 *23* 10.)

(W. M. Fletcher and F. G. Hopkins, *Journ. Physiol.* 1906 *35* 247.)

Professorship of Physiology, 1883

1. Sir Michael Foster (1836–1907), Trinity 1883
2. John Newport Langley (1852–1925), St. John's 1903
3. Sir Joseph Barcroft, King's 1925

Quick Professorship of Biology of the Cell, 1931

1. David Keilin 1931

Hales's Windmill Ventilator at Newgate (p. 290).

XII

PATHOLOGY

At St. Bartholomew's Hospital in 1714 it was ordered that stones taken out of patients should be hung up in the Compting House for the governors to see. This was the start of a Pathological Museum.

From time to time Regius Professors had given lectures on Pathology, e.g. Haviland, Bond, and Humphrey. In 1879 a memorial signed by 138 graduates engaged in the study or practice of medicine was addressed to the University Commissioners praying that provision might be made for the study of Pathology and of other medical subjects. As a result a Grace in 1883 established a whole-time chair. The department began in two small rooms over the old Physiological Department. In 1889 it moved to the old chemical laboratory by Corn Exchange Street. In 1901 it moved to premises in St. Tibb's Row, and in 1904 to new quarters in the new Medical School. Finally in 1928 the present fine Pathological Department in Tennis Court Road was planned and erected with the generous aid of the Rockefeller Trustees.

PROFESSORSHIP OF PATHOLOGY, 1883

1. CHARLES SMART ROY (1854–97) (St. Andrews and Edinb.) 1884
2. ALFREDO ANTUNES KANTHACK (1863–98) (St. John's) 1897
3. Sir GERMAN SIMS WOODHEAD (1855–1912) (Edinb.) 1899
4. HENRY ROY DEAN (1879) (Master of Trinity Hall) 1922

APOTHECARIES AND MATERIA MEDICA

In Anglo-Saxon Cambridge a general medical practitioner would have been known as a 'leech': later he became an 'apothecary'. The Art of the Apothecary was learnt during an apprenticeship for a period of ten years, as appears in the case of Richard Smith in 1501. 'Chymists and Druggists' did not appear before the second half of the eighteenth century: John Smithes Crosley, of Cambridge, who had such a title at the time of his death in 1707, was one of the early ones.

The old quarter of the apothecaries seems to have been to the East of St. Mary's churchyard, where already in 1475 John Esewell, apothecary, held a lease of land then 'noisome from stench'.

In the sixteenth century the apothecaries were a part of the Grocers' Company, an association which was traceable until a few years ago in the case of a house at the South-east corner of the Market-place, which was inhabited by several generations of apothecaries named Vesey, and which was ornamented with the arms of the Grocers' Company.

The Apothecaries' Company was founded in the early part of the reign of James I, and in Cambridge, at all events, the members made money.

Richard Love died c. 1600 leaving over £1,000, including £800 of savings. He leased a plot of land from the churchwardens of St. Mary's. His son became Master of Corpus Christi College.

John Swetson, *d.* c. 1630, must have been well connected, for his widow Dorcas had Dr. Robert Eade, fellow of Caius, as executor and left him in 1641 her best satin petticoat laced with gold. To Gostling, another physician, she left the gold ring on her finger, and to Joseph Loveland, fellow of Trinity, she left £1 for a ring and £1 for a sermon.

The study of Wills of medical men made by Dr. Palmer of Linton has revealed much intimate detail relating to the early practitioners. For instance:

Thomas Brydon died in 1589, leaving drugs to the value of 27*s.* 10*d.*

Also the following items:

Two nests of boxes, containing boxes and the seed in them 5*s*., 25 great boxes 4*s*., 8 rounde standing boxes and 34 boxes 2*s*., 32 gallipots 5*s*., 36 glasses 3*s*., 7 oyle potts 2*s*.

4 brazen mortars weighing 9 score and 10 lb. at 3*d*. £2 6*s*. 0*d*., 4 pestles weighing 20 lb. 3*s*. 4*d*.

Marble mortar and a marble grynding store and a muller 3*s*. 4*d*. 7 pairs of scales.

3½ cwt. of lead and 19 pounds of brazen weights £1 16*s*.

7 great staining pots 4*s*. 2 dialls, a box and a sheaf of arrows 2 styllatories 6*s*. 8*d*. Lead and a styllatorye of lead 20*s*.

From the list and quantities of drugs mentioned in his inventory, Dr. Palmer reckoned Brydon an elegant pharmacist, for he had no nauseous remedies but administered medicines chiefly by means of conserves or confections. He had 9 lb. of conserve of barberries, worth 1*s*. a pound. Culpepper advocated the use of barberries to get a man a stomach for his victuals. Conserves of cherries and roses were his agreeable and mild flavourings. When he needed anything stronger there were Angelica, caraways, and cummin seed, also 'pepper, cloves, cinnamon, prunes, raysons and other spices'.

For ointments for external use there were Stavesacre seeds, doubtless used to rid the heads of Cambridge schoolchildren from unpleasant guests. Also the following:

Lapis calaminaris	Diachylon plaster
Red and yellow wax	Oil of exceter
Spermaceti	Green trett
Oil of roses	Plaister called 'Gratia Dei'.

Mr. Price, apothecary, bled Mr. Cole in March 1780.

'Thos: Rochell, apothecarie,' is described as 'late servant to John Poley, apothecarie' of Cambridge.

Thomas Day died in 1681, worth £1,500, not counting the value of his house and farm property. The contents of his shop, drugs, oils, ointments, evators, syrups, conserves, confections, lectuaries, plasters and powders, pots, stills, alembicks, and skillets were worth £100.

Martin Buck, who died later in the seventeenth century, left silver catheters and other instruments which

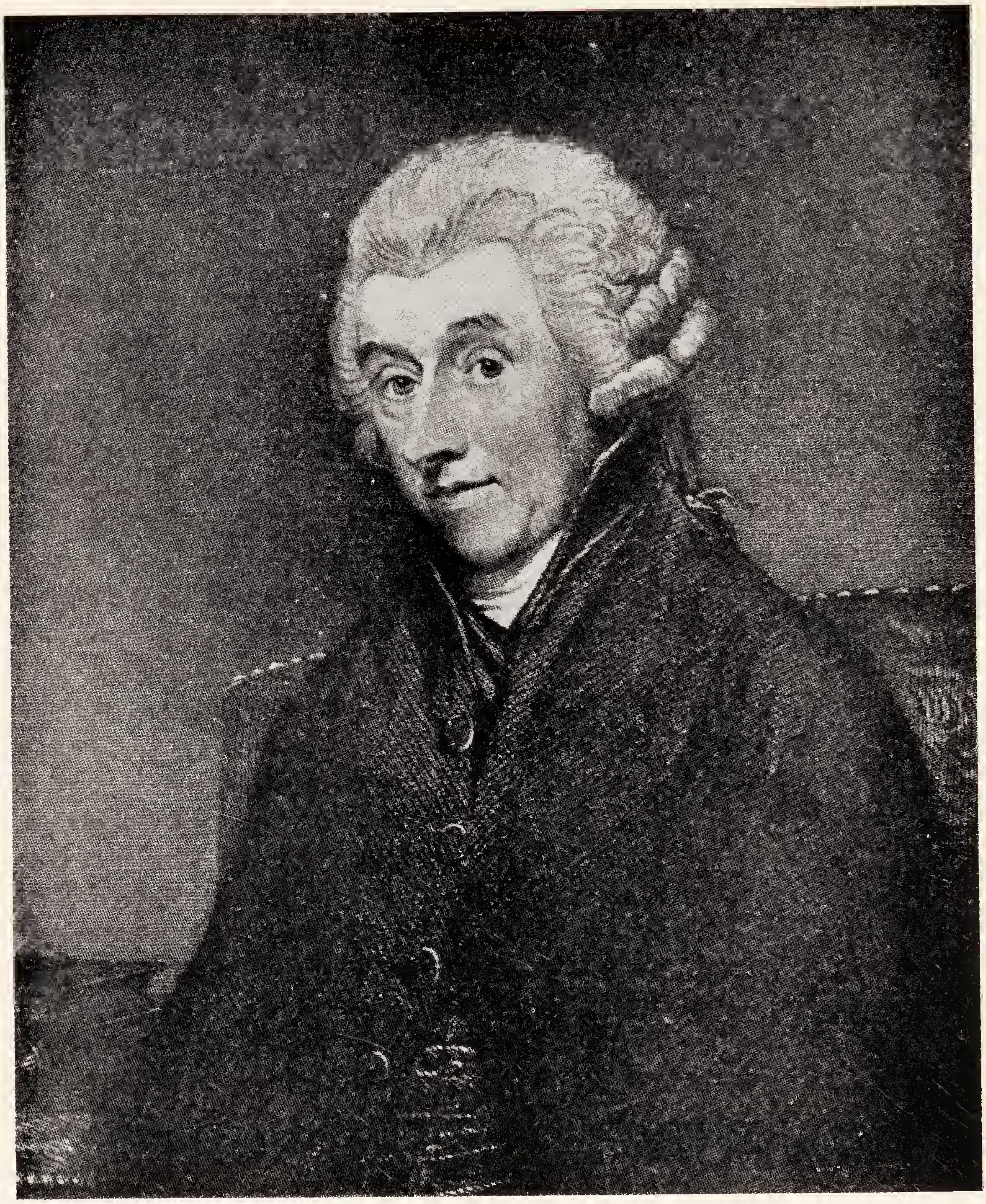
suggest that the practice of the apothecary was more lucrative than that of contemporary surgeons.

Peter Dent was a botanist well known to John Ray.

One side of the Apothecary's Art is at present most admirably illustrated in Cambridge by the long series of Mortars which have been collected by the industry of Mr. E. Savile Peck, M.A., Ph.C., and by Sir William Pope. Several of the more noteworthy specimens in these collections have been figured and described in *Notes upon a Cambridge Collection of Bell Metal Mortars* published as a communication to the Cambridge Antiquarian Society for 1932.

A fair series of Drug pots, and a few interesting ceramic Pill Slabs painted with the arms and motto of the Apothecaries' Company are contained in the Fitzwilliam Museum.

Towards the close of the seventeenth century, and at the beginning of the eighteenth, so large a body of knowledge of Materia Medica had been accumulated that the importance of a closer study was being realized at both Universities. The great range of vegetable, animal, and mineral substances that were supposed to have some medicinal virtue was known from such books as Culpeper's *Herbal* and, more officially, from the *Pharmacopeia* edited for the London College of Physicians. An early lecturer at Cambridge was John Francis Vigani, the first professor of Chemistry, who is believed to have obtained his pharmaceutical knowledge when travelling abroad. Certainly in 1704, the year after his appointment to the professorship, he obtained a collection of drugs from Francis Porter, a druggist in London. On Jan. 15 of that year, these were sent down by Mr. Martin, the Cambridge carrier, with a note 'I could not get several of the things viz. black lead Spongia . . . fennell and Portingale jar. . . . no good Spanish saffron to be had . . .' The list of 30 drugs includes myrrh, tamarinds, manna, aloes, liquorice, and opium. Further consignments were sent in February and May addressed to Poley Clopton, fellow of Queens'. A cabinet of 26 small drawers and 3 larger ones was provided for the collection at a cost of £10. Mr. Peck, through whose researches these notes are taken, dates two papers used for trays at 1698 and after 1714 respectively. It has



WILLIAM HEBERDEN THE ELDER, M.D., F.R.S.

By courtesy of St. John's College

therefore been possible to distinguish with some probability between original specimens and later additions. The later accessions may have been received about 1730, when Professor R. Bentley gave his *Course of Lectures upon the Materia Medica, Antient and Modern, read in the Physics Schools at Cambridge upon the Collections of Dr. Attinbrooke and Signor Vigani deposited in Catharine Hall and Queens' College*, 1730. (See pages 472 and 490).

Yet a third collection in the library of St. John's College was formed by Dr. W. Heberden to illustrate the thirty-one lectures which are listed in his folio prospectus—

THE ORDER OF A COURSE OF LECTURES[1] ON THE *MATERIA MEDICA*

LECT.

1. INTRODUCTORY Lecture, giving a general account of the rise and progress of the Materia Medica.

Of FOSSILS.

2. Of Waters.
3. Of Mineral Waters.
4. Of Earths, Sulphurs, Fossil Oyls, Bitumens and Amber.
5. Of Sea-Salt, Alum, Nitre, Borax and Vitriol: Of the Ores of Metals.
6. Of Quicksilver, and of Semimetals.
7. Of the perfect Metals.

Of VEGETABLES.

8. Of Stones.
9. Of the Aromatic Herbs, Leaves, Flowers, Seeds, Barks and Woods.
10. Of the Aromatic Roots: Of the Acrid Herbs, Fruits, Seeds and Roots.
11. Of the Astringent Flowers, Fruits, Seeds, Barks, Woods and Roots.
12. Of the Peruvian Bark.
13. Of the Emollient Fruits, Seeds and Roots.
14. A general account of the use of purging medicines: of the purging inspissate Juices.
15. Of the purging Herbs, Leaves, Flowers, Fruits, Seeds, Barks, Woods and Roots.

[1] The first course began April 7, 1747 and ended May 22. Heberden 'left off a week between the 10th and 11th lectures for Newmarket Races'.

16. A general account of the use of Emetics: Of the Emetic Herbs, Seeds, Barks and Roots: of Diuretics.
17. Of Narcotics and Opium.
18. Of Vulneraries, &c.
19. Of Gums: And a general account of Resins.
20. Of Balsams, Turpentines and Resins.

Of ANIMALS.

21. Of Insects, Fishes, and Birds.
22. Of the Serpent-kind, Quadrupeds and Man.

Of CHEMICALS.

23. Explication of some Terms used in Chemistry.
24. Of the simple and compound Waters, Essential and Fixed Salts, Soaps, Caustic Stones, Expressed and Essential Oyls; Of the Preparations of Turpentine.
25. Of Spirit of Wine, Spirituous Waters of Vegetables, Vinegar, Tartar and its Preparations, Tinctures and Chemical Resins.
26. Of Ammoniac Salt, Spirit of Ammoniac Salt and Hart's Horn, Spiritus Volatilis Oleosus, Animal Oyl and Phosphorus.
27. Of Spirits of Sea-Salt, Nitre and Vitriol; Of the Preparations of Sulphur, Steel, Lead, Tin, Silver and Copper.
28. Of the Mercurial and Antimonial Preparations.
29. General Rules for Prescribing.
30. 31. Of the Antidotes [proper] to all the known Poisons.

[In this Course a specimen of each Particular is shown, and every Thing is intended to be mentioned that is useful or curious regarding its Natural History, Introduction into the Materia Medica, Adulterations, Preparations, Virtues, Dose and the Cautions necessary to be observed in its use.

These Lectures will begin on *Monday, April the 4th* [1748] at 2 o'clock in the Afternoon, in the Anatomy Schools; and will be read every day, By W. HEBERDEN, M.D.]

The First Course is Two Guineas; *the Second*, One Guinea; *ever after*, Gratis. [*Those Gentlemen, who intend to go, are desir'd to send in their Names.*]

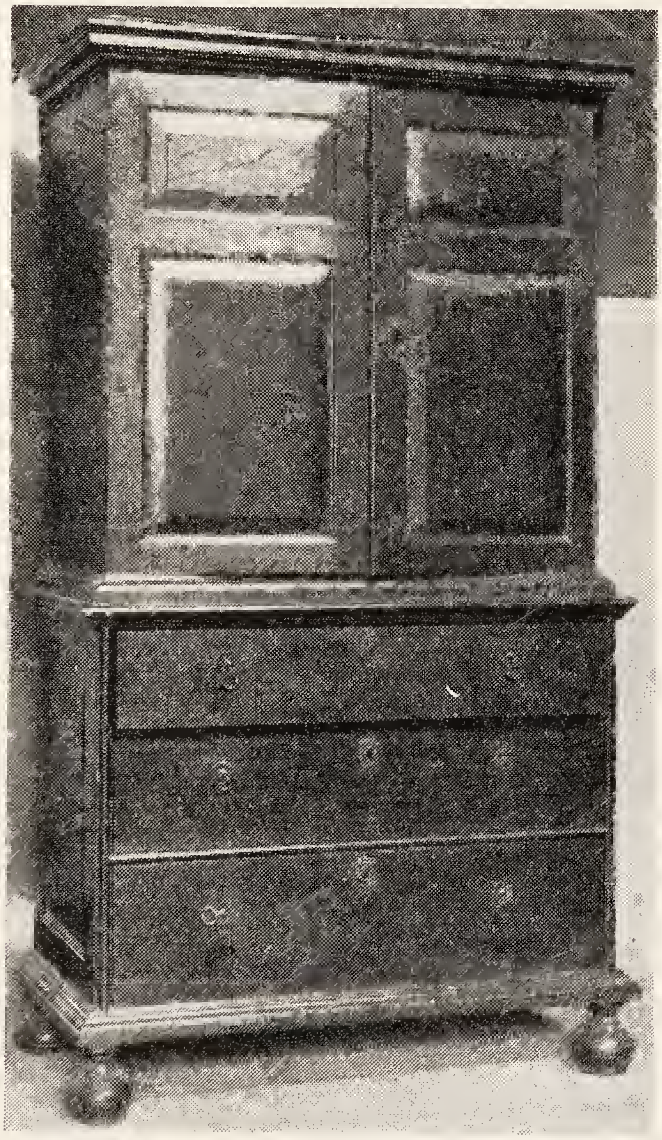
JOHN MARTYN, professor of Botany 1732–68, is credited with having introduced valerian, peppermint water, and

black currants into pharmacy. His botanical work will receive notice on p. 392.

252. The Vigani Cabinet of Materia Medica. 1703–4.

Queens' College.

About 600 specimens contained in 26 drawers enclosed by two doors, over three large drawers in a cabinet of oak.



Described, with facsimiles of the original bills, by E. Saville Peck, *Cambr. Antiq. Soc.* 1934. *See* p. 473.

253. The Addenbrooke Cabinet of Materia Medica. 1690–1700.

See p. 490. St. Catharine's College.

254. The Heberden Cabinet of Materia Medica. c. 1748.

See p. 482. St. John's College.

255. Medicine Mortar and Pestle. Marked 'M. E. H'.
Sedgwick Museum.

8 inches high. From Arco Wood Farm, Horton in Ribblesdale.

256. Medicine Mortar. Marked 'W'. 1688.
Sedgwick Museum.

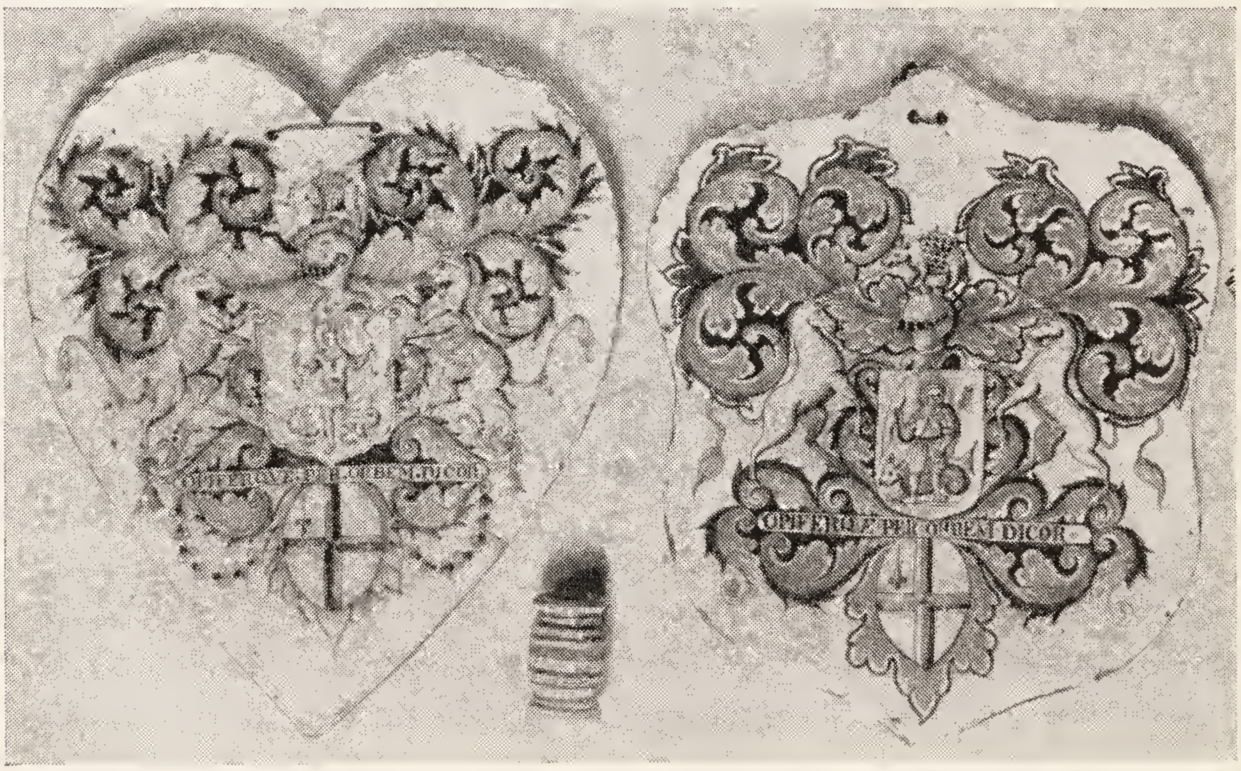
Cut out of Silurian Sandstone. Collected by Professor Hughes at Abergele, N. Wales. *Cambridge Graphic*, Jan. 19, 1901.

257. Ditto, not marked, from near St. Asaph.

258. Series of Mortars.
Sir William Pope and Mr. E. S. Peck.

259. Drug Pots. 17th cent.
Sir William Pope and Mr. E. S. Peck.

260. Pill Slabs. 18th cent.
Fitzwilliam Museum.



The glazed tiles upon which apothecaries of the 18th century used to roll their pills. Painted with the armorial bearings, and motto OPIFERQUE PER ORBEM DICOR of the Apothecaries' Company. Two also bear the shield of the City of London.

NO. 260. PILL SLABS

Fig. 1. $3\frac{1}{2}'' \times 5''$. Egyptian, 14th cent.

Fig. 2. $9'' \times 11''$. Made by Henry Knight of Reading, 1618

Fig. 3. $5'' \times 7\frac{1}{2}''$. Made by Edward Neale of Burford, 1658

Fig. 4. $6'' \times 6\frac{1}{2}''$. Dutch, 1660

NO. 258. APOTHECARIES' MORTARS

From E. Savile Peck's Collection

XIII

ZOOLOGY

The early Zoologists of Cambridgeshire were the farmers, the hunters, the butchers, the gamekeepers, and the sportsmen, in fact all who lived in the country and took intelligent interest in the birds and beasts of the country-side. They were the men who knew. But they hardly realized the value of recorded knowledge; the pen was but an awkward implement in their fists. In any case they preferred to hand on their experiences by word of mouth. On the other hand, those who wrote usually lacked knowledge. They too often abstracted what they could gather from the bestiaries of the Dark Ages,[1] with frequent additions to the ancient fables. Like poets and painters they had the infinite capacity of the artist for romancing. In the Middle Ages the favourite collection of such zoological romances was the *Physiologus*—a corpus of tales and fables relating to animals, which were intended to be used by preachers for enlivening their sermons. But the quaint pictures with which that work was illustrated had and have still a great attraction.

Advance in the direction of scientific Zoology was impossible before naturalists had learnt that zoological truth is only to be sought

in Truth's own Book,
The creatures, which by God Himself was writ.

To study Nature and eschew uncorroborated book-learning must be the rule of every zoological writer. On surer ground were the practical treatises handed down from antiquity for the instruction of farmers, such as those of

[1] Excellent examples are MSS. Caius 109, 372, 384.

Columella, Palladius, and the old Roman writers *De Re Rustica*. These stimulated the production of similar works in English, some of which are referred to in the section on Husbandry, p. 402. Worthy of honourable mention too were the early works on Bees and Bee-keeping.

Early records often shed unexpected light on the knowledge of olden times. For instance in 1374 the Hastings family held a manor by the service of carrying a goshawk at the Coronation. An Act of Parliament of 1532–3 prohibited Clergy under the degree of Doctor from wearing 'black cony, boge, grey cony shankes, calaber gray fiche, foxe, lambe, otter and bever', which suggest the zoological knowledge of the furrier of that day. Such instances could readily be greatly multiplied.

But the first man at a University to teach only what he himself could see, and make his students see, was *Vesalius*, the founder of modern Anatomy. Vesalius, a native of Brussels, was teaching at Padua from 1537 onwards, but although his great work on the Structure of the Human Body was the beacon that showed the way, Zürich rather than Padua supplied the guide to the first scientific zoologists of Cambridge.

Zürich became the hub of the zoological universe owing to the work of CONRAD GESNER (1516–65), author of the great *Historia Animalium*, a man of encyclopaedic knowledge whose high reputation attracted many students of zoology, and scholars from all over Europe were glad to correspond with him on scientific matters.

Among those who sought Gesner's acquaintance were Edward Wotton, of Oxford, and the three Cambridge naturalists, WILLIAM TURNER of Pembroke (1510–68), JOHN CAIUS (1510–73), and THOMAS PENNY of Trinity (1550, *d.* 1589).

The first of this trio visited Gesner at Zürich, and wrote him a letter on British Fishes. Caius wrote a chapter on English Dogs for the *Historia Animalium*, but Gesner unfortunately dying before it could be printed, its author issued it as a separate publication, *De Canibus Britannicis*, in 1570. An English translation *Of Englishe Dogges* was made by Abraham Fleming six years later. The youngest of the three, Thomas Penny, actually spent a part of his

Wanderjahre working with Gesner, and is believed to have been with him when he died. According to Sir Arthur Shipley he certainly helped to arrange the master's natural history collections, and, what is more to the point, appears to have brought Gesner's drawings of Butterflies to this country for further study.

Caius was one of those who had already imbibed the principles and methods of Vesalius at Padua, and his work for medicine is mentioned on p. 247. The beginning of zoological studies at Cambridge may be said to have begun with William Turner of Pembroke Hall, whose botanical work was widely read and generally esteemed. His work on Birds, *Avium Praecipuarum quarum apud Plinium et Aristotelem mentio est, brevis et succincta historia* was published in 1544 and dedicated to Edward Prince of Wales, afterwards Edward VI. As the title declared, the book was based on Pliny and Aristotle, but Turner 'added notes from his own experience on some species which had come under his observation, and in so doing he has produced the first book on Birds which treats them in anything like a modern scientific spirit . . . nor is it too much to say that almost every page bears witness to a personal knowledge of the subject, which would be distinctly creditable even to a modern ornithologist.' (A. H. Evans, *Turner on Birds*.)

As Dean of Wells in 1550 he achieved considerable distinction, holding office until religious controversy made it untenable for so polemical a churchman opposed to Queen Mary's views.

Thomas Penny matriculated at Queens' in 1546, but transferred to Trinity, where he became a fellow in 1553, and bursar in 1554. Taking orders, he was appointed Prebend of Newington in St. Paul's Cathedral, but being unable to adapt his religion to the changing fashions of those days, was in 1565 found to be 'ill-affected towards the Established Church'. This determined him definitely to begin to study medicine, first in Paris, but later at Zürich, where he became intimate with Gesner, 'the most comprehensive scholar of his age'. After Gesner's death in 1565, Penny, continuing studies at Montpellier, included entomology and botany, and made a collecting trip to

Majorca for the purpose. In 1570 he set up in practice as a physician in London, but found opportunity for herborizing in the north and east of England.

But entomology became the chief interest of his life. When in Zürich he had already examined a quantity of unpublished material, illustrated with drawings of insects, which Gesner had laboriously extracted from some four hundred authors. Penny obtained additional information from the brothers Jacob and Peter Quickelberg of Antwerp, from the great botanists Clusius and Camerarius, who were also interested in insects, and in this country from Sir Edmund Knivett 'famous for his curious search into natural history', Peter Turner, and William Brewer. But an even greater friend and admirer was Dr. Thomas Moffett, his junior by twenty years, at Trinity. To some extent they co-operated as partners in the practice of medicine, and made entomological excursions together in the vicinity of London. On one of these walks in a wood in Essex they examined a wasps' nest: 'not without great peril to our lives'. Moffett says: 'I would needs be prying into the nest, which so offended the swarm that they rushed out upon us, and it was a great while before they would leave pursuing us.' Penny received specimens of beetles and diptera from correspondents overseas. Dr. E. Elmer collected in Russia, Ludovicus Armacus on the Guinea Coast, White in Virginia. At the end of fifteen years' arduous collecting and study Penny's constitution became so weakened that in 1588 he died, having failed to complete his task.

By his will he left his accumulated papers on insects to his friend Moffett. Had they been published then, the book would have been the first book on Entomology to be issued to the world.

Another naturalist was John Maplet of Queens', who became fellow of Caius in 1566 and soon after produced a Natural History entitled *A Green Forest; wherein may be seene, the sufferaigne vertues of all kinde of Stones and Metals; next of Plants, as of Herbes, Trees, and Shrubs; lastly of Brute Beasts, Fowls, Creeping Wormes & Serpents, and that alphabetically*. London 1567.

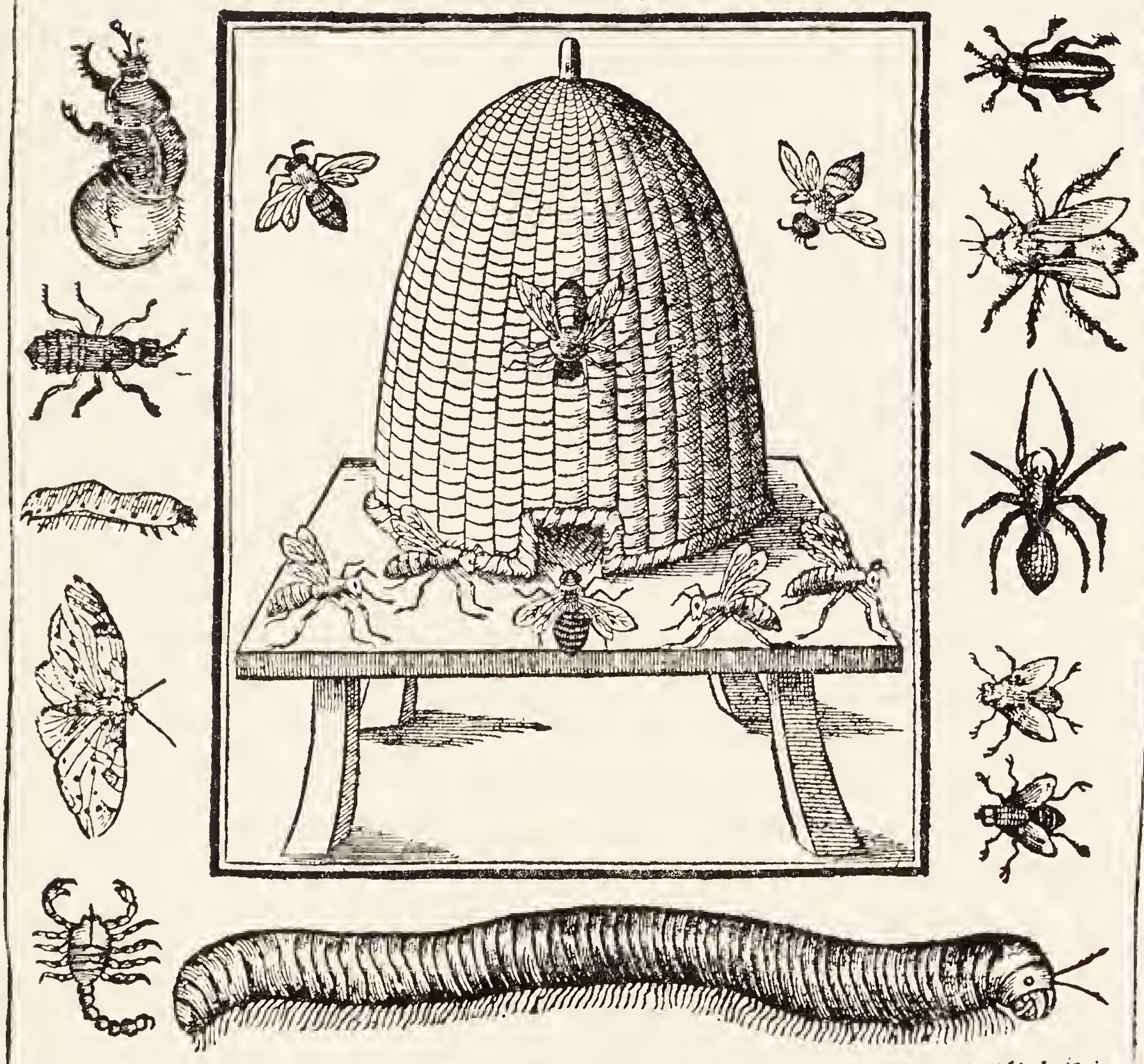
Among the pupils of Caius was Thomas Moffett (1553–

INSECTORVM
SIVE
Minimorum Animalium
THEATRVM:

Olim ab

EDOARDO WOTTONO.
CONRADO GESNERO
THOMAQVE PENNIO
inchoatum

Tandem
THO. MOVFETI Londinâtis operâ sumptibusq; maximis concinnatum, auctum, perfectum:
Et ad vivum expressis Iconibus suprà quingentis illustratum.



Londini ex Officinâ typographicâ *Thom. Cotes*. Et venales extant apud *Guiliel. Hope*, ad insigne Chirothecæ, prope regium Excambium. 1634.

1604) of Trinity College in 1569, but of Gonville and Caius College in 1572. He died in 1604.

After taking an M.D. degree at Basel, Moffett proceeded in 1579 to Spain and Italy, where he studied the Silkworm[1] and collected further notes on the natural history of Insects. On his return to England he became possessed of the entomological writings of Edward Wotton and of his Trinity friend, Penny. To do honour to Penny he spent fourteen months in arranging the manuscript on 1,200 folio pages, giving it the title *Insectorum Theatrum, Olim ab Edoardo Wottono, Conrado Gesnero, Thomaque Pennio positum nunc Tho: Moffeti opere sumtibusque aedificatum et egregiis Iconibus illustratum.*

'I have forged the history', he wrote in his preface, 'to the best of my abilities, adding at the same time the light of oratory which Penny lacked. I have mended the method and the language. . . . I have also inserted entire histories of insects and above 150 pictures which Gesner and Penny knew not.'

It was a great work, but years elapsed before any printer could be found to undertake it. In the meantime the bulky volume of Aldrovandus, *De Animalis Insectis*, 1602, appeared and Moffett died in 1604. Sir Theodosius de Mayerne bought the MS. and laid it by, so that it did not go to the press until thirty years after Moffett's death, when it appeared under the title of *Insectorum sive Minimorum Animalium Theatrum . . . ad vivum expressis Iconibus supra quingentis illustratum*, 1634. Engraved portraits of Wotton, Penny, and Moffett adorn the frontispiece. One hundred and three years after the death of Wotton this work, which he was the first to begin, appeared in English as an appendix to Topsell's *History of Serpents* in 1658.

Edward Topsell (matric. Christ's 1587, *d.* 1625) had also been a close student of the great work of Conrad Gesner, part of which he abstracted and printed under the title of *The History of Foure-Footed Beastes*, 1607, followed by a lengthy explanation:

'Describing the true and lively figure of every Beast, with a Discourse of theire severall Names, Conditions,

[1] A poem entitled *The Silkwormes and their Flies*, 1599, has been attributed to him.

Kindes, Vertues (both naturall and medicinall), Countries of their breed, their love and hate to Mankinde, and the wonderfull worke of God in their Creation, Preservation and Destruction.' The book was clearly

> Necessary for all Divines and Students, because the story of every Beast is amplified with Narrations out of *Scriptures, Fathers, Phylosophers, Physicians,* and *Poets*: wherein are declared divers *Hieroglyphicks, Emblems, Epigrams* and other good *Histories,* Collected out of all the volumes of CONRADUS GESNERUS, and all other Writers to this present day.

And then in 1608 he published *The Historie of Serpents.*

In the early part of the seventeenth century, as at other times, showmen occasionally toured East Anglia with uncommon beasts, generally from foreign parts, thus giving the local people perhaps their only chance of first-hand experience of exotic or remarkable creatures. An interest in animals was thus kindled in the minds of the young, and undergraduates are always young.

On one historic occasion (c. 1625) a famous Bull arrived at Cambridge with the intention that it should be baited at Gogmagog Hills, where 'Olympic Games' were to be practised for a month or six weeks. However, the Vice-Chancellor is stated to have banned the sport. At a rather later date Th. Ward was indicted for having gone about the country with a lion, which he showed at Sturbridge fair.

A more remarkable circumstance is recorded in a letter from Mead of Christ's College, dated 24 June, 1626.

> 'I will now tell you of an accident here at Cambridge, rare if not strange, whereof I was yesterday morning an eye witnesse myselfe: a book in *decimo sexto* of the bigger size found in the maw of a codfish, then opened in our fishmarket in the presence of many. In the same was two peeces of saile-cloth; one half an ell at the least, of unequall bredth, but in some part very broad; the other about halfe a yard long of the bredth of a pudding bagg; these found wrapped in the bottome of the stomach, the book above them . . . I saw all with mine owne eyes, the fish, the maw, the peeces of sayle cloth, the book, and observed all I have written. Onely I saw not the

opening of the fish, which yet many did. . . The fish came from Lynne.'[1]

Among popular zoological writings few had a greater vogue than the English translation of Pliny's great Natural History. It is therefore pleasant to record that on 11 April 1636 Dr. Smith, Vice-Chancellor, granted the following licence in favour of DR. PHILEMON HOLLAND, fellow of Trinity 1575, *d.* 1636, the translator of Pliny.

'In consideration of the learning and worthy parts of Dr. Philemond Holland, and in commiseration of his want of meanes to relieve him now in his old age, I have given leave, that he shall receive such charitable Benevolence as the M^{r} and Fellows of every Colledge, shall be pleased to bestow upon him.

H[ENRY] S[MITH] Procan.

Dr. Holland is 84 yeares old, Pupill to Dr. Whitgift, fellow of a Colledge, Master of the King's Free Schole in Coventrye for 20 yeares, & commenced Doctor 40 yeares since. He translated divers books, and for 60 years kept good hospitality, *sit tota Coventria testis* & by age being disabled to travell abroade and practise, and confin'd to his chamber, he is impoverished and indebted, having had a great charge of children.[2]

The 'books alone of his turning into English will make a Country Gentleman a competent library for historians'. So wrote Fuller.

At Midsummer fair in 1711 were to be seen a fire-eater, a giant, a dwarf, wild beasts, dancing dogs, three-legg'd cats. Cf. 'Verses at the last Publick Commencement at Cambridge written by Mr. L. Eusden 2nd edit. London 1715.'

The foundations of the two sciences of Ornithology and Ichthyology were laid by the joint labours of Ray and Willughby. Together they studied; together they travelled, and together they collected. FRANCIS WILLUGHBY, of Trinity 1652, the younger of the two, and at first the other's pupil, seems to have gradually become master; but dying before the promise of his life was fulfilled, at the age of 37 in 1672, his writings were given to the world by his friend and executor, Ray. They had recognized that a

[1] Heywood and Wright, *Univ. Transactions*, ii. 346.
[2] MS. Baker xxxiii. 224.

thorough reform of the treatment of both vegetable and animal kingdoms had become necessary. Literature had become overburdened with citations and puerile fables, extracted from the ancient writers. They perceived the futility of unsupported speculation, and determined that their descriptions should be confined to facts. Moreover, they arranged the various forms of life according to structure. One of the first results, and perhaps the most important, of their method was that having recognized the 'species' as such, they defined this term, and fixed it as the base from which all sound zoological knowledge has to start.

Two of Willughby's early papers, published in the Philosophical Transactions, were *On a kind of Wasp called 'Ichneumons'* and *On the Hatching of a kind of Bee lodged in old Willows.* Willughby died young, and so few of his letters have been preserved that these four to Courthope[1] are worthy of record. Both were Trinity men: both became Fellows of the Royal Society.

I.

ffor his most Honred Cosen Peter Courthope Esquire at Cambridge these.

Seal [Owl]. [?165–]

Sr, I give you very manie thanks for your speedie return, and for your kindnesse in inquiring after my ffather. I found him when I came home recovering of a fit of ye goutt. Hee was perfectly well within a day or 2, and since has continued so. I was greivously chidden when I last writ for not putting in their services which you now have, and must alwaies understand when not expressed. I am allso to thanke you for your care of ye Poore Grecian and for disbursing some mony for mee which my sister wil repay when you see her. It has been part of my worke since I came home to take exact notes out of Cambden of all ye monasteries, castles, families, old roman townes and other remarkable things, which I would fain have you doe to, and if ever we travel together again, it wil bee very profitable to confer notes. You may for shortnesse use *f.* for family, *f:o:* where there is a town of ye same name. *Me:* medalls, *mo:* monastery etc. If you go about it you must get ye folio Cambden & read it seriously from one end to tother. Poore Don has utterly cast away himself, without his freinds consent. He now begins to be ashamed of it, and

[1] Peter Courthope born at Cranbrook, succeeded in 1657 to his grandfather's estate of Danny Park. His mother was a Miss Burrell and his daughter Barbara married Henry Campion, in whose family Danny and the letters still remain.

would faine have it concealed, and I beleeve when you see him at London you will have much adoe to make him confesse it. This I allow you to tell Mr. Linnet & Mr. Wray & no body else.

I doubt you wil bee gone from London before I shall be there, which I intend not til May. I have resolved upon a little Expedition into Kent, and if it bee not possible to meet with you otherwise I shall not vallue ye riding of 40 mile to Danny. I should be glad to heare where & how you mean to spend this summer.

I desire you when you come to London to enquire at ye Greyhound in Grais-Inne-lane for Mr. Alured, and if he bee not there whether he bee alive and wel. and so leave your letter for me at Hornes. I would not have you forget my service to Mr Greswold & Mr. Disny[1] (being my countriemen) as allso to Mr. Linnet etc

Your most affectionate & faithful freind & servant

ff: W:

I thinke it were best for ye Eruca when warm weather comes to be exposed somtimes to ye sun for Her diet and other things I leave Her wholy to your discretion. I should be glad to heare you were acquainted with O: Wilkins & engaged in the Character Designe, if you bee, you must not faile to carry my very Humble Service.[2]

2.

ffor His most honred cosen Peter Courthope Esquire to bee left at Mrs. Fages an Apothecaries shop at the sign of ye Sugar loafe neere the Conduit in Fleetstreet.

London. 3d. Seal [Owl]

Sr, manie businesses falling out have deferred my Journey to London longer than I expected; but I am absolutely resolved to bee there about the end of May at the furthest. I give you thanks for your seeds & last kind letter, and desire my heartie service to your relations at Dannie. Ye usuall commends from hence attend you with Sancos who is now here.

Your most affectionate faithful freind & servant ff: W:

3.

[Addressed to the same 'Fage' address]

Sr, I am now at Oxford where I intend to stay a month. I have agreed for myselfe at a Private House for so much a Weeke, and for you to, if you come. You cannot but know your company is Hugely desired if you dare venture your self with a sizant again.

Your most faithfull freind & servant

ff. W.

You may hear of mee at the Grey Hound.

[1] William Disney, Fellow of Trinity 1645, Tutor 1646–52, Vice-Master 1654–5.

[2] Dr. Wilkins of Oxford and his design for a *Universal Character*. He became Master of Trinity 1659–60.

4.

[To the same 'Fage' address] [Post Mark] $\frac{No.}{13}$ [1662]

Sr I never heard word of you since I saw you at London till iust now in a letter from Mr. Wray that brings me the verie ill newes of your Ague, for which I am most heartily sorry, but doubt not but your youth and courage will bravely overcome it, the best course is no Phisick, a verie spare Diet, warmth and to cheare up your spirrits as much as you can. I have lately taken a resolution of following Signor, this Winter and the next summer will be spent in Preparation and in dispatching a great manie things that must first be done. The beginning of the year after is the time I designe. You must not speake a word of it till we meet, nor communicate it to anie, unless you see Mr. Wray. Either or both of you shall have your free choice and I thinke there is never another or but one now that can be thought of.[1] I shall very much desire to heare from you, nor could there anie thing come more acceptable then that you were well delivered. With my service to all your Honred relations I remain your most faithfull freind & servant ff: W:

John Ray published as their joint work the *Ornithologia* in Latin in 1676, and in English, with many emendations, in 1678.

In this work there are good notes on the internal anatomy, the habits and the eggs of the birds described. Birds generally were grouped in two great divisions—'Land-fowl' and 'Water-fowl'—the former being subdivided into those which have a crooked beak and talons, and those which have a straighter bill and claws; while the latter are separated into those which frequent waters and watery places, and those that swim in the water—each subdivision being further broken up into many sections, to the whole of which a key was given. Thus it became possible for almost any diligent reader, without much chance of error, to refer to its proper place nearly every bird he was likely to meet with. Ray's interest in ornithology continued, and in 1694 he completed a *Synopsis Methodica Avium*, which, through the fault of the booksellers to whom it was entrusted, was not published till 1713, when Derham gave it to the world. (Newton.)

It is on record that Thomas Pennant owed his interest in natural history to a perusal of this book as a boy.

Two of the three early letters that Wray wrote to his friend Peter Courthope of Danny were written when Wray

[1] Cf. Wray's letter to Courthope, No. 17, 4 Sept. 1662.

was holding a six months' tutorship to the son of Thomas Bacon at Friston Hall in Suffolk. Both contain references to East Anglian birds. A portion of the first letter has been printed as No. 19 in the *Further Correspondence of John Ray* published by the Ray Society in 1928.

Two letters from John Ray to Peter Courthope of Danny

I. Friston Jan. 20, 1662.

Sr, I received your letter, and had wrote to you to London, but that yr departure was so near. Indeed nothing is to me more pleasant, in this retirement and distance from my former friends, than to heare from and to write to them. I cannot entertain my time more pleasantly, nor spend my thoughts upon a more gratefull subject. Therefore you see though I have no businesse, yet rather than not write I can be content to be impertinent and to wast paper upon any thing whatever comes next hand, though not much materiall, and of no concernment to you. It falls out well to my content that you are pleased so chearfully to entertain, and kindly resent these well intended, though very importune expressions of my devotion and affection, these paper-presents. I doubt whether for your own ease, who are in danger to be overcharged with them. I have now spent about halfe the time I have to bestow in this place, and I am not sorry for it, not because I mislike any usage or entertainment here, that is unexceptionable; nor could I hope to be treated more civilly, or gain more kindnesse and respect anywhere, but because I am somewhat overcharged with businesse of another nature than what I should spontaneously and of my own instinct pursue. I have consented to bestowe upon the family a short discourse in Divinity every Sunday. Some reason they have to desire it of me, their pastor being a weak old man, somewhat below the elevation of yours, and his sermons are jejune. He likewise exactly repeats the same words in the afternoon, without addition or alteration duly.

The young gentleman with whom I am charged hath very good parts and a quick wit. He hath broken out into some extravagancies at Cambridge, and that caused his father to take him home; he is impatient of labour, and indeed his temper will not admit long study. I doe not well approve his naturall constitution, yet despair not that he will *ad bonam*

frugem se recipere. I must needs with gratitude acknowledge and commend his kindnesse, civility and respectful carriage towards me, whom he studies, as much as he can, to please, gratify and oblige.

I busie myselfe in enquiring out and describing such birds as frequent the channel near us. I have gotten some and cased them, among the rest a Bittern and a Curlew. I remember some yeares agoe at Mr. Nids chamber in Trinity Coll. I was present at the dissection of 4 Birds. The names of three of them were a Bittern, a Curlew and a Yarwelp; the fourth was like a duck, with a bill hooked at the tip, for which we had no name. The Yarwelp[1] is a name that I never read or heard of before or since, and therefore imagine it was coined by William Bates. I have also almost quite forgotten the shape and colour of it. The Curlew I have also lost the memory of in a great measure; and fancied it a different thing from the Bird which passeth under that name here, wch is gray all over like some ducks and hath an extraordinary long bill bending downward like a bow. I guesse it is called in Latine *Arcuata.* If you have any notion or memory of these birds (whose cases hung up in the cupboards over Mr. Nid's portall), I pray send me your notion of them in writing, especially of the Curlew and Yarwelp.

We have a bird here, which also lives *circa aquas* about the bignesse of a Woodcock, and having a bill in proportion longer and slenderer than it, gray upon the head, back, breast, wings which some heerabouts call a Stone plover, possibly this bird may be the same with that *Yarwhelp.* The gray is like the gray of a Quail, or of some ducks, not made up of a mixture of white and black.

I not long since received a letter from Mr. Willughby, wherein he assures me of his firme adherence to his resolution for travel, and that he hath almost conquered all opposition of his friends, and made his way clear; he despairs of your company, and relies upon me, and I intend not to frustrate him. I am told your house's [Danny] old master the Earle of Norwich is dead; it falls out well for Mr. Willughby (as I remember), his father paid him a considerable annuity out of the estate. If you be resolved to sell Danny, I wish you may meet with a chapman

[1] *Limosa lapponica,* the bar-tailed Godwit, from its cry on taking wing.

to your content that will come up to your terms, which I presume are not unreasonable. I fear that businesse will not be transacted and setled so soon as the urgency of our journey requires, I mean so soon as it will be needfull for us to set forth. The time now approaches.

I should be glad to hear of the health and welfare of your relations known to me, especially the much honoured your mother, not omitting the little child etc. My humble service to them all, and thankes for their civilities and kindnesse when I was in Sussex.

I will not presume to write you any further newes from hence, and this countrey affords none. I have not heard from my friend T. B[urrell] since I left Cambridge. When you see any of his, I pray, forget not my service and respects to them. It is time now to take leave, having no more then to assure you that I am

Sr

Yrs most devoted in all service Jo: Wray

2. These ffor the Wo^pfull Peter Courthope Esqire at ye Sugar-loafe in Fleet street near the Conduit — London.

Sr,

Friston Feb. 16, 1662.

Mr. Skippon acquainting me that you intended to stay yet a fortnight in London, I could not patiently deferre my answer till your returne into the Country. I perceive now by yr information, that the Curlew of Cambridge is the same bird which with us here passeth undr that name viz *Arcuata Gesneri*. I had quite lost the idea of it, and imagined it another kind of thing: the other species I see cannot be retrived. As for the birds you mention, I have no bookes of the history of animals here, but only Gesner, and therefore can give you no good account of them. The name of Shoveler I have heard of, here, but not yet seen the foul that ownes it: it is rare hereabouts, and stayes not upon this coast long after Michaelmas (as our fowlers tell me). Mr. Willughby in one of his letters to me containing a catalogue of what foules he gate in Lincolnshire the last summer, hath one which possibly may be the same with this. He calls it in Latine *Anas platyrhyncha erythropos*, in English a Stockard, and addes by way of description, that the upper mandible towards the end is a great deal broader

and not so compresse as in Ducks, but arched. Gesner makes the English Shoveler a kind of Pelecane. No better account can I give you of the Raile. Take of this also from Mr. Willughby in the mentioned letter, which jumps with and confirms your judgement. [Water Rail, *Gallinula Serica* sive *Rallus aquaticus*, it hath a little black bald]. This is one of his Catalogue, and I dare say ye same with yours. I am intending this spring before I goe over, to prick a sheet by way of appendix to the Catal. Cantabr: which shall contain some addenda and emendenda; if you have observed any errours therein, I pray be pleased ingenuously to deale with me in communicating them: if you goe to Edw. Morgans, enquire of him concerning *Androsamum Hypericoides*, for as I remember he denied that plant which I called by that name to be rightly by me named. About this I have also written to Mr. Skippon more at large, whom if you happen again to see, I pray S^r conferre with him about it. I doubt not but he hath acquainted you with Dr. Merett's design of putting out a new *Phytologia Brittanica*. I hope I shall get liberty to wait upon you before I goe 'tother side the channell, and enjoy a little of your society and converse, but cannot certainly promise myselfe so much happiness, because I foresee that I shall be straitened by time, being engaged here till Lady day next. I wish that your affaires could be settled with that expedition our hast requires, but that is a fond velleity. Your company would be worth staying for moneths and yeares, but that neither could we be secure of it if we should stay, and a little delay now might possible quite frustrate our design

I am, S^r Yours in all service most devoted Jo: Wray.

The French Macreuse and Scotch Barnacle were one of the topics discussed by Ray with Dr. Tancred Robinson (1658–1748) of St. John's College, who in the year when he took his M.D. degree contributed a paper thereon to the Philosophical Transactions for 1685.

A new era in the history of Ichthyology also commenced with the work of Ray and Willughby.

The *Historia Piscium*, 1686, which bears Willughby's name on the title-page, was clearly their joint production. A great part of the observations contained in it were collected during their common journeys in Great Britain and

on the Continent, and it is no exaggeration to say that at that time these two Englishmen knew the fishes of the Continent, especially those of Germany, better than any other Continental zoologist. It also includes many original observations on the fishes of the Mediterranean.

By the definition of fishes as animals with blood, breathing by gills, provided with a single ventricle of the heart, covered with scales or naked, the Cetaceans are excluded. Yet, at a later period, Ray appears to have been afraid of so great an innovation as the separation of whales from fishes, and therefore he invented a definition of fish to comprise both. The fishes proper are then arranged in the first place according to the cartilaginous or osseous nature of the skeleton; further subdivisions being formed with regard to the general form of the body, the presence or absence of ventral fins, the soft or spinous structure of the dorsal rays, the number of dorsal fins, &c. Not less than 420 species are thus arranged and described, of which about 180 were known to the author from autopsy, a comparatively small proportion, descriptions and figures still forming at that time in a great measure a substitute for collections and museums.

Ray does not appear to have obtained the manuscript materials for the third work, the History of Insects, until too late in the last two years of his life, when his physical infirmities prevented him from doing justice either to himself or to his subject. He did, however, draw up a *Methodus Insectorum* which was printed soon after his decease. The larger work was eventually produced in 1710 under the editorship of Dr. Derham. The paragraphs derived from Willughby's entomological papers are all marked 'F.W.' 'The work is a mass of accurate and authentic observation, but for want of plates has never come into popular use.'

To this work an appendix was added on British Beetles *ex MSS. Musaei Ashmoleani* by Martin Lister.

The following letters from Ray to Timothy Burrell are preserved in the Trinity College Library. They are excellent specimens of the neat penmanship of the writer, and the one of 1694 reflects the interest that the more advanced naturalists were beginning to take in internal parasites.

For Mr. Timothy Burrell at Cuckfield, in Sussex.

Black Notley July 22.—90.

Sr

My very good friend & neighbour Mr Middleton leaving this countrey, & going to be your Vicar at Cuckfield gives me a fair opportunity of sending a few lines to you, with design to revive our ancient friendship, wch by long omission of all intercourse & correspondence may needs languish, though scarce by any length of time on my part to be utterly extinguished. The impressions of affection, wch your excellent endowments of mind, & that dignitas oris or gracefulnesse of person, wherwith, not to dissemble my weaknesse, I was not a little taken, & ye Relation you stood in to me, wrought in me, are so deep & lasting.

As for what concerns my self, if you still retain so great a kindnesse for me, as to desire to know any thing of my present condition or former life, take this short Account. You may remember, that ye rigorous exacting from all that were admitted to any office or employment in ye Church such oaths & subscriptions as my scrupulosity would not permit me to take, excluded me from the exercise of the ministeriall function, to wch I was by my education designed, & had also actually engaged my self in. Whereupon I made bold, & perhaps too bold, to spend a good part of my time in pursuit of other studies, especially naturall History, to wch I was most propense, wherein what I have performed may possibly not be unknown to you, though I have no reason to boast but rather to be ashamed of it.

From the time of my ejection out of the University, for the space of five years I lived an ambulatory life; whereof being weary, I settled with Mr Fr. Willughby at Middleton in Warwickshire. After his death I entred into a married estate, wherein continued eleven years without issue, & then pleased God to give me children, first two at a birth & then two more single ones, the youngest of which is not a year & half old, & the eldest not six years, all daughters. I doe at present (I thank God) enjoy a competent measure of health, only am often troubled with colds, the Air I live in being, I think, too sharp for me. The last spring so violent a cough & destillation seized me as threatned life, & was not easily mastered by all the methods & means my self could devise, or friends advise me to; the dregs whereof are not yet quite purged out of my blood.

As for maintenance I have by the liberality of Mr Willughby sufficient to support me during life, without being burthensome to my friends: & my condition though not splendid, nor fortunes affluent, yet is tolerable enough not to say easy to me. But no more of my self at present.

Mr Middleton informs me that you have married the second time, & that your present Lady is daughter to Sr Job Charleton a Gentleman well known to me, as was also his second lady, mother I suppose to yours, an excellently well qualified, & very pious Gentlewoman, whom I am glad to hear yours also doth in all her good qualities & perfections nearly resemble. I heartily wish you much joy together, & that (wch I hear you as yet want) a fair issue & posterity.

Mr Middleton, that brings you this Letter I shall not recommend to you, he needs it not. Yet I cannot forbear to say, that he is one of the best ministers, & the best men that I know; & I doubt not but, upon experience you will find him so, & treat him accordingly.

If you think good to gratifie me with any thing in answer please to send by Post, & direct your Lr to Black Notley near Braintree in Essex for Sr Your very affectionate friend & humble Servt John Ray.

To Mr. Ray

'Tis now a considerable time since I was favoured with your last obliging letter to one who had less good nature than you have. I should be concerned to excuse my not making a more early acknowledgment, but you have too much to put me in any pain upon a point of ceremony. And perhaps in right reckoning I ought rather to bespeak your patience and your pardon when I interrupt you with repeating so often my obligations and my thanks, saying nothing new—Heaven itself is wont to bear with such sort of address.—And in consideration with the Licence you have given me, incourage me still to persist. I had indeed sooner inquired of your health if my worthy good friend Mr. Middleton's information of it, and an inexpressible grief for the loss of my dear wife, had not stopped my hand. I have, Sr, in some of my melancholic hours been diverted by the Tracts I have of yours, and particularly your *Synopsis Animalium*[1] etc., wherein I observe your opinion noted agst Equivocall Generation f. 15, and confirmd by many arguments & great authors, yet if I had sense I would ask if that species of worm bred in human bodies observed to be generated els-where, for I should think it will be hard to say their eggs are conveyed out of one Man or one Horse into another. And of Phthiriasis, which I suppose is where worms are bred in ye flesh, and which happens to one single man in a nation, and that once perhaps in a 100 years, will be more difficultly answered when that species of worm or lice doe conceale & preserve themselves and light at length upon this single person. But on f. 4, § 33 'tis said by somebody sequimur non quâ veritas sed qua ratio trahit, whether it be applicable here or no, I pretend not to determine. I observe likewise f. 200 you say quod non verisimile videtur quod . . . Animal a natura ita factum esse ut cibi deglutiti parum aliquam vomitu semper aut etiam frequenter rejicere debent. I should acc[ordingly] inquire whether ye castings of Hawks, which you know constantly throw up lumps of flix or feathers or down (the wild or well . . . reclaimed) bring any of the food up with them. In f. 309 I presume is an error in the print, Hirundines for Hirudines.

[1] Ray dedicated his *Synopsis Methodica Animalium* to Peter Courthope and Timothy Burrell.

JOHN RAY

W. Faithorne, pinx: W. Elder, sculp.

You see how confidently, not to say impudently, I trouble you with what I myself can't believe will deserve your considering, but however it shows you I read what you give me, (tho not with that advantage which a man of a wiser head would doe). But 'tis an evidence likewise that I rely very much upon our candor and friendship to forgive such impertinencies of

Sr, your most affection[t] obliged friend
& faithful servt
T. B[urrell].

9 Jan. 1694.

[MS. R. 4. 42 Trin. Coll. Cambridge.

To this Ray replied with the letter printed in facsimile on page 354.

Stimulated no doubt by the work of Edward Tyson on Pygmies, JOSHUA BARNES of Emmanuel College published in 1675 a small work entitled *Gerania* on the 'Discovery of a little sort of people'.

Dr. MARTIN LISTER (1638–1711), fellow of St. John's in 1660, was a prolific contributor to the Philosophical Transactions on zoological subjects—especially on the Invertebrata. His more important works were *Historiae Animalium tres Tractatus; unus de Araneis; alter de Cochleis terrestribus et fluviatilibus; tertius de Cochleis marinis.* London, 1678. *Exercitatio Anatomica de Cochleis maxime terrestribus et Limacibus.* London 1694. *Exercitatio tertia Conchyliorum Bivalvium.* London 1696. His *Journey to Paris*, 1698, has been reprinted.

He left his library and collection of shells to the old Ashmolean Museum at Oxford, where the present writer restored the inscription recording his gift over the library door. The collection of shells, which must have contained all the type specimens figured in his books, has been lost.

A fashion for the study of the lowlier forms of life had set in, and even Roger North of Jesus, c. 1683, observed the habits of spiders, which he kept in 'wide-mouthed glasses, such as men keep tobacco in'. (*Lives of the Norths*, ii. 285 b.)

Sr,

I received the sad news of the death of your hond Lady from Mr Middleton when he was heer last Summer: by him I was also informed what a pious end she made, whereat I was exceeding glad. I suppose you have by this time well concocted your grief, and therefore it would be unseasonable for me to suggest any consolatory consideration, which would serve rather to refresh then moderate your sorrow.

Your objections agst some particulars in my Synopsis Animalium &c I acknowledge to be very material & of difficult solution. As for the first about the castings of Hawks, though they be frequent, & common to the Wild as well as reclaimed, yet I think they are not of the primary intention of Nature, but only for remedy of an inconvenience. For wild Hawks when they catch Birds, being for ye most part hungry, bestow not that time & pains they ought to doe in pluming of them, but together with the flesh swallow a great deal of down & feathers, wch the stomach cannot readily subdue, so that by its volutation therein it is amassed together in a lump or pill, as we see tophi frequently concreted in calves stomachs of ye hairs they swallow. this pill not being capable of descending down the guts, lest by the coacervation of many of them they should cloy the stomach, is rejected by vomit.

To the second concerning the generation of Insects in the bodies of Animals I have nothing better to answer then what you may find set down in my Book intitled The Wisdome of God &c pag. 57 & 58th of ye second Edition: wch is indeed nothing but that I doe believe ye eggs or seeds of such Insects are conveyed into ye bodies of Animals, though I know not the manner how.

I was in hopes I should before this time have presented you with my Synopsis methodica Avium & Piscium: the Copy whereof hath been delivered to my Bookseller a year agoe. But he is very dilatory & hath not as yet put it to ye presse, because perchance he doubts the sale: & therefore I am not urgent with him.

I have for this whole Winter troubled with a Diarrhaea, wch after I have stopt ~~awhile~~ by ye use of Laudane & other means for a while, returns again upon me. I have likewise sores still upon one of my legs, to which this long continuing cold is not propitious. these ails & infirmities doe or ought to put me in mind of my approaching fate. this wth humble prayers for you is all present from

Black Notley
March 13. – 94.

Sr, (Yours in all offices of love
& service John Ray.)

Please to give my service to
Mr Middleton & his Wife when
you happen to see them

The zoological achievements of members of the University were doubtless more considerable than our evidence shows, but that some acknowledgement of their efforts may be made we quote the following items of zoological interest.

In 1751 William Chafin, an undergraduate of Emmanuel College, on November 1 or 2 saw and shot near Andover 25 Bustards. (*Newton's Life*, p. 211.)

In the same month in the seventeen sixties a stag turned out at Chesterford entered the New Gardens near St. Peter's College, leaped over a wall, and made its way to the Nine Wells, where it was captured, and from thence taken back to Chesterford. (London newspaper.)

On 17 June 1765 a large Carp was caught in a ditch near Midsummer Green measuring 31 inches and weighing nearly 13 lb. (*Cambridge Chronicle*, 22 June 1765.)

On 15 November 1777 a hunted stag took refuge in one of the staircases of St. John's College. It had been turned out at Chesterford by the old Walden hunt and after a fine run, came to the Backs, crossed the river and ran through the streets with his pursuers close upon him. (*Cambridge Chronicle*, 22 November 1777.)

A Carp living in the pond at Emmanuel College in 1783 had been known for 36 years. It had lost one eye, but knew and would approach its feeder. (Walton, *Compleat Angler*, ed. Rennie, 145.) And when the same college celebrated the bicentenary of its foundation on 29 September 1784, 'several lively turtles were kept in tubs of water at the Master's Lodge, to the edification of the public, and also of the woman who asked "Pray, Sir, are them real turtles or mock turtles?". (Gunning, *Reminiscences*.)

Among the unusual pets that were occasionally kept in Colleges was the tame magpie whose conversational talents were much appreciated in Magdalene about 1785. But it came to a bad end by falling into a pail of punch and not being discovered until after the pail had been set upon the table.

In 1782 the Professor of Botany, THOMAS MARTYN, published the *Heads of a Course of Lectures in Natural History read at the Botanical Gardens*, which lectures were arranged under three divisions: I. Animals, classed after Linnaeus, with the improvements of Pennant in the Quadrupeds and

Birds. II. Vegetables. III. Fossils, after the method of Professor Wallerius of Upsala.

The study of Insects made very material progress through the publication of the works of William Kirby (1759–1850) of Caius who founded the order of Strepsiptera for *Stylops kirbii* in 1811. As the author of *Monographia Apum Angliae* 1802 and, with W. Spence, of the much used *Introduction to Entomology* 1815–26, he became F.R.S. in 1818, and with John George Children (1777–1852) was an early fellow of the Entomological Society. The last named had studied mechanics, electricity, and mineralogy at Cambridge, and was appointed first Keeper of the Zoological Department of the British Museum in 1837.

A more original thinker who has attained a great reputation was Thomas Robert Malthus, 1766–1834, of Jesus College, who maintained the general principle that throughout nature, in plants, animals, and man, procreation is stronger than the possibilities of maintaining life. Zoologists will always remember him because his work suggested to Darwin his great theory. Darwin felt 'on reading Malthus, *On Population*, that natural selection was the inevitable result of the rapid increase of all organic beings, for such rapid increase necessarily leads to the struggle for existence'. It is interesting to note that the birthplaces of our two greatest exponents of population problems, Malthus and my former pupil Carr-Saunders, were situated within a few yards of one another at Dorking.

But otherwise, from the period of Ray at the end of the sixteenth century to the middle of the nineteenth century, history does not record any very notable activity among Cambridge Zoologists. It was evidently a period of rest, while nature was gathering strength for achievements such as have not been equalled at any other University. And again Christ's College was the academic birthplace of one who, as Dr. Shipley of that college has truly said, was destined to alter our conceptions of organic life more profoundly than any other man has ever altered them.

Born at Shrewsbury on 12 February 1809 Charles Darwin was admitted into Christ's College on 15 October 1827 and came into residence in Lent Term 1828. Cambridge, however, can make no more claim to having trained

him as a naturalist during his undergraduate years than that he there attended botanical lectures and excursions, and walks with Henslow. But in a postgraduate term, by Henslow's advice, he read geology and made the acquaintance of Adam Sedgwick. Then came the offer of a place for a young naturalist from Captain Fitzroy of the *Beagle*, and the historic cruise from 1831 to 1836. He dwelt in Gower Street from 1839 to 1842, and at Dover from 1842 to 1882.

The publication of *The Origin of Species*, 1859, and perhaps still more *The Descent of Man* led to the more intensive study of zoology from new points of view.

We may here pause to survey once again the attractions of the nearer Cambridge country to the naturalist even as late as 1850.

'In going over the land now occupied by Downing-terrace, you generally got five or six shots at snipes. Crossing the Leys, you entered on Cow-fen; this abounded with snipes. Walking through the osier-bed on the Trumpington side of the brook, you frequently met with a partridge, and now and then a pheasant. From thence to the lower end of Pemberton's garden was one continued marsh, which afforded plenty of snipes, and in the month of March a hare or two. If you chose to keep on by the side of the river, you came to Harston-Ham, well known to sportsmen; and at no great distance from this you arrived at Foulmire Mere, which produced a great variety of wildfowl. The heavy coach changed horses at the Swan, and would set you down, between 7 and 8 o'clock at the Blue Boar.

If you started from the other corner of Parker's Piece, you came to Cherryhinton Fen; from thence to Teversham, Quy, Bottisham and Swaffham Fens. In taking this beat, you met with great varieties of wildfowl, bitterns, plovers of every description, ruffs and reeves, and not unfrequently pheasants. If you did not go very near the mansions of the few country gentlemen who resided in the neighbourhood, you met with no interruption. You scarcely ever saw the gamekeeper, but met with a great number of young lads, who were on the look-out for sportsmen from the University, whose game they carried, and to whom they furnished long poles to enable them to leap those very wide ditches which intersected the Fens in every

direction. I am happy to say that these incentives to idleness no longer exist. Thousands and tens of thousands of acres of land, which at the time I speak of produced to the owners only turf and sedge [1786], are now [1850] bearing most luxuriant crops of corn. . . .

The sport which the Fens afforded, and of which I was so fond, unfortunately could be pursued with success during every month of the year. A very common practice, during the spring and summer months, was for a party to divide into two sets, one on a shooting scheme, and the other on a boating and fishing expedition, both parties agreeing to meet and dine at Clayhithe. There was a public-house on each side of the river, where fish was dressed to perfection, the charges were very moderate, and the ALE very good. The fishing-party (who frequently went as far as Upware, and occasionally to Dimmock's Court) scarcely ever failed to get an abundance of fish; but if they were unfortunate, the landlord of the smaller house had well-stored ponds, from which the deficiency was quickly and amply supplied. Some of the party were in the habit of gambling in the following way:—they bargained with the proprietor of these ponds to be allowed to keep all the fish they caught at a single throw, or any number of throws, for a sum agreed on: the sum varied from half-a-crown to a guinea, according to the size of the net, the skill of the caster, the state of the ponds, and the number of throws. Two things were remarkable; though some splendid pike and perch were occasionally caught, yet the proprietor was always a winner. Sometimes I have been called out to see a person land an enormous fish which was visibly enclosed in the net. In his anxiety to make sure of his prize, he thankfully followed the advice or gladly accepted the assistance of a good-natured bystander, who was smoking his pipe by the side of the water, and who was usually a friend of the landlord; it is scarcely necessary to add, that with such an assistant the huge fish generally escaped.

The following all achieved distinction as Entomologists:

THOMAS VERNON WOLLASTON (1822–78), Jesus, M.A. 1849, wrote more than sixty papers on insects, chiefly Coleoptera. He was a friend of Darwin and produced a book *On the Variation of Species* in 1856, three years before Darwin's *Origin of Species* was read. Wollaston's

monographs on the fauna of Madeira and other Atlantic islands, where he had collected beetles, were his best-known works.

JOSEPH WILLIAM DUNNING (1833–97), whilst at Trinity, helped to prepare the *Accentuated List of British Lepidoptera* 1858. He was President of the Entomological Society in 1883–4.

DAVID SHARP (1840–1922). From 1885 Curator of the University Museum and editor of *Insecta* in the *Zoological Record.*

THOMAS DE GREY, 6th LORD WALSINGHAM, F.R.I. (1843–1919), Trinity. Collector of Microlepidoptera.

FREDERICK DU CANE GODMAN (1834–1919), Trinity. Co-editor of *Biologia Centrali-americana.*

Accurate detailed descriptions of bodily structure with a view to a comparison of the various organs in different animals was the principal object of the school of Comparative Anatomists.

The attitude of the University to zoological studies underwent a great change after the historic controversy between Professors Owen and Huxley at the Cambridge meeting of the British Association in 1862. The primary incentive to an improvement was the need of providing adequate accommodation for the valuable zoological collections then in the university. The need of a professorship was hardly less obvious. The museum was built in 1865, and ALFRED NEWTON (1829–1907) of Magdalene was elected first professor of Zoology and Comparative Anatomy in 1866.

Professor Stanley Gardiner has put it on record that Newton's department consisted of a room for himself, where he used to meet all who cared to come, conducting informal classes. 'Arthur Balfour used to say that he enjoyed these, and he introduced his younger brother FRANCIS MAITLAND BALFOUR, 1851–82, who in the next ten years established embryology as a distinct division of animal science.'

Having as a student studied the development of the chick, he went out to work at Dohrn's newly-founded Zoological Station at Naples, where he advanced our knowledge of the development of Elasmobranch fishes. On re-

turning to Cambridge he was rewarded by a fellowship at Trinity and devoted himself to abstracting and digesting all that had been published on the Embryology of Animals The result was the *Treatise on Comparative Embryology*, 1880, a work that raised the Cambridge school in the estimation of the learned world as few other Zoological works had done.

Newton lent F. M. Balfour his private room for practical classes in 1875, and the University created a chair of animal morphology for him in May 1882, but he lost his life when climbing a spur of Mont Blanc two months later. Among his pupils in this period were SEDGWICK, GARROD, MILNES MARSHALL, BRIDGE, HICKSON, LISTER, WELDON, HARMER, SHIPLEY, and BATESON.

Balfour's teaching, though not his professorship, was continued by ADAM SEDGWICK, first as lecturer and then reader at a salary of £100 a year, Trinity College providing a fellowship and other emoluments. King's, Christ's, St. John's and Caius also gave material assistance to the new Department. When the ranks of those needing practical instruction in zoology were swelled by the medical students, the University found accommodation by raising the roofs over the Department of Mineralogy and over the Philosophical Library, providing large and most picturesque attics for practical zoology. ADAM SEDGWICK, 1854–1913, of Trinity, succeeded Newton as professor for two years. He will always be remembered for his great *Textbook* and for his classic researches on *Peripatus* and thereby on the connexion of the Arthropods with lower forms of life. He also occupied the Zoology chair in the new Imperial College of Science from 1909 till his death.

WALTER FRANK RAPHAEL WELDON (1860–1906), St. John's, co-founder of *Biometrika* with Karl Pearson, succeeded Ray Lankester in 1900 as Linacre Professor of Comparative Anatomy at Oxford: and in 1909 STANLEY GARDINER succeeded to the Cambridge Chair.

For a quarter of a century the Professor's own room had to serve as office, research laboratory, and storeroom all at once, while the expanding classes in comparative physiology, entomology, and hydro-biology occupied such space where and when it could be obtained in 'a ramshackle and wide-

spread laboratory, no part of which was even reasonably fireproof, or suitable for that experimentation which the modern development of zoology makes imperative'. Moreover there were in 1932–3 400 students and 36 research workers to be accommodated.

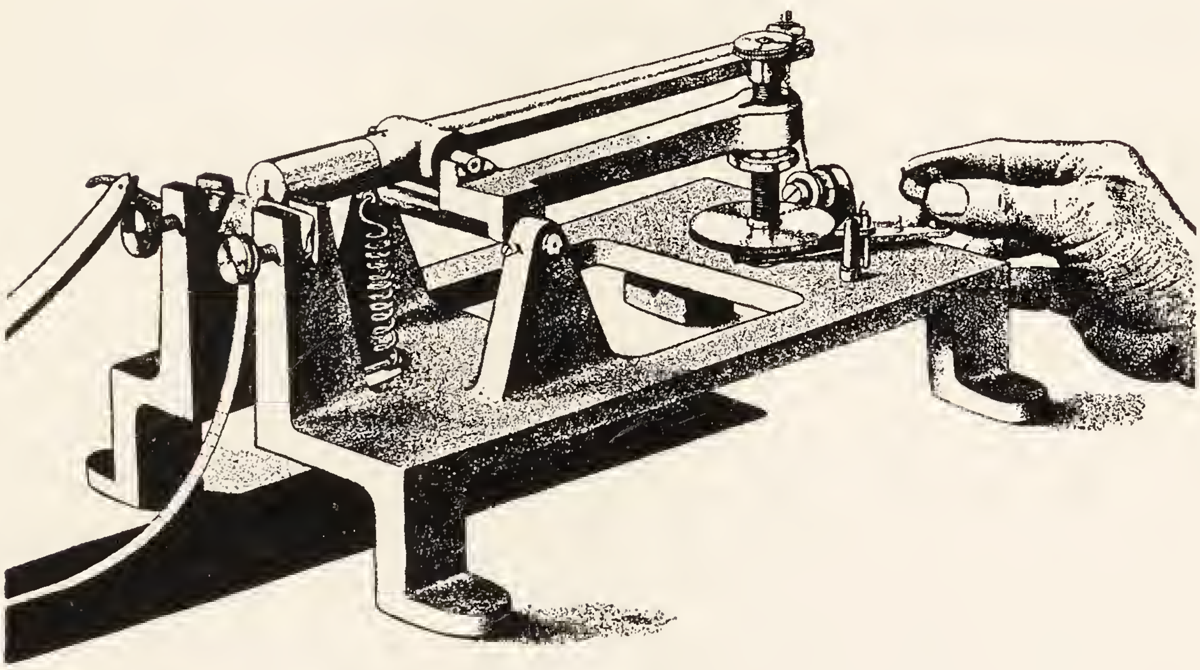
Palatial new buildings were built with the aid of a Rockefeller grant and were opened in October 1934.

Professorship of Zoology and Comparative Anatomy, 1866

1.	Alfred Newton	1866
2.	Adam Sedgwick	1907
3.	John Stanley Gardiner	1909

Professorship of Biology

1.	William Bateson	1908
2.	Reginald Crundall Punnett	1910–12



The Cambridge Rocking Microtome 1885.

See p. 365.

HISTORIC INSTRUMENTS IN THE ZOOLOGICAL LABORATORY

Among the instruments associated with the earlier workers in the Zoological Laboratory are the following:—

261. Case of dissecting instruments.
By 'A. Weiss & Son, 287 Oxford Street, London'.

261a. Case of four bone-mounted cataract and other dissecting needles. c. 1870.

262. Sliding Microtome for celluloid method. c. 1880.
By 'R. FULCHER, CAMBRIDGE'.
On brass base.

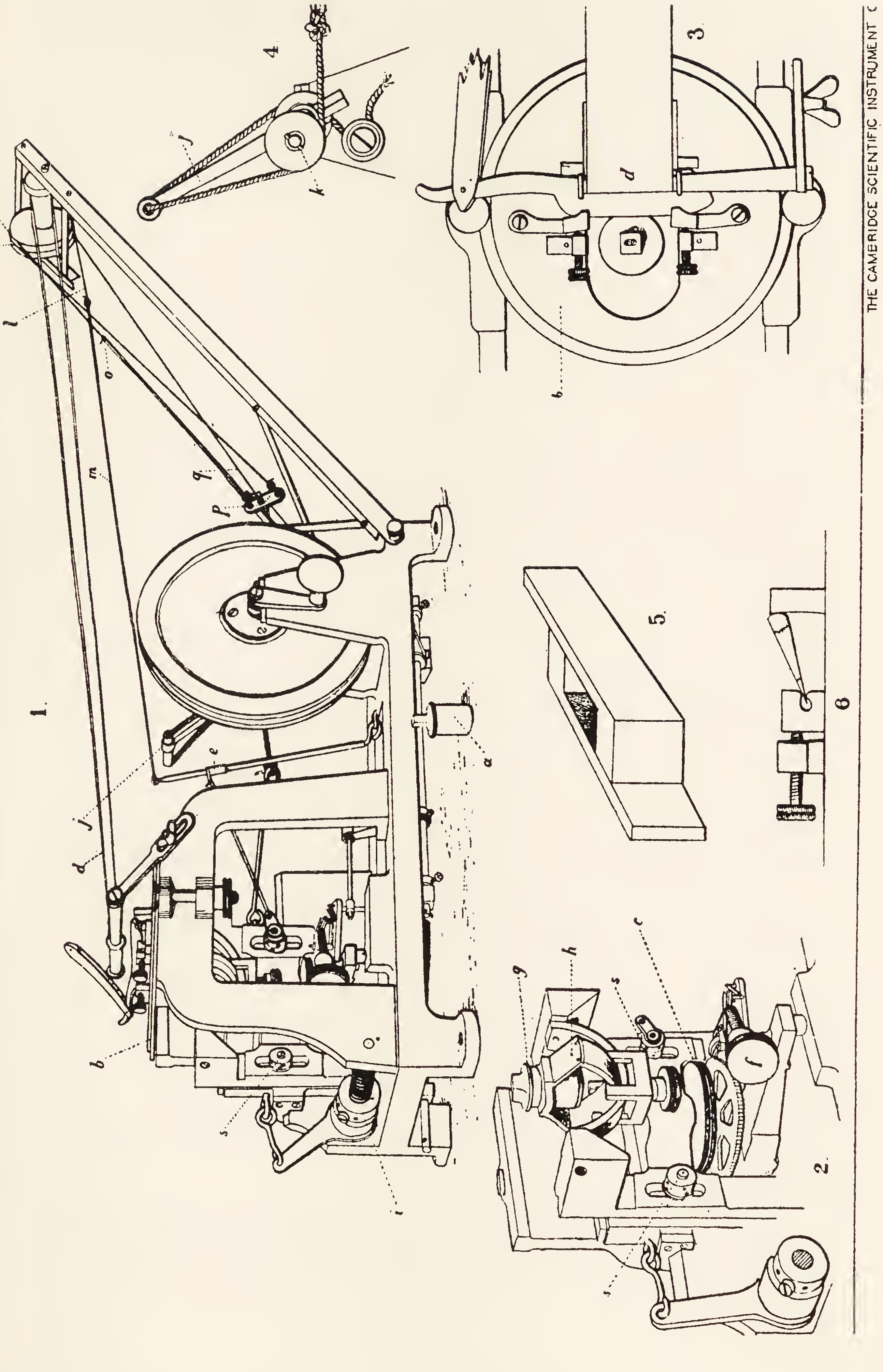
263. Hand-cutting freezer-microtome on two pillars.
By 'C. Zeiss, Jena'. c. 1880.

264. Caldwell-Threlfall Automatic Microtome.
1883–4.

Length 3 feet. The original instrument, constructed by W. H. Caldwell with Sir Richard Threlfall in the workshop of the Cavendish Laboratory. Caldwell had discovered the method of imbedding in paraffin in 1881.

The following account has been contributed by Mr. R. S. Whipple:

Sir Richard Threlfall states in his paper 'The Origin of the Automatic Microtome' (see *Biological Reviews*, vol. v, page 357, 1930) that W. H. Caldwell told him in May 1882 that he had observed that when cutting by hand sections of embryological specimens mounted in paraffin wax, that if the wax was at the right consistency in relation to the temperature at which it was cut, the section adhered to the razor at the sharp edge of the blade, and did not adhere elsewhere. By cutting a second section without moving the first from the razor, the second section welded itself to the first and pushed it across the razor. This discovery made the construction of a section-cutting machine a possibility. With regard to the machine Threlfall writes


1.
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THE CAMBRIDGE SCIENTIFIC INSTRUMENT C

as follows:—'I proceeded to get out drawings showing the machine substantially as constructed, though, as I was (and still am) a very poor draughtsman, the drawings were redrawn in Prof. Stuart's work shop, where I had arranged that the machine was to be constructed at my expense. The machine was put in hand during the Michaelmas Term, 1882, and completed [by Ruffett] during the Easter Term, 1883.' The machine remained at work in the laboratory of Comparative Anatomy for many years.

The Cambridge Scientific Instrument Co. brought out a modified form of the machine of which five or six were made. The following is an extract from a catalogue published by this Company in December, 1883.

'Microtome, Caldwell's Automatic. This machine has been perfected from the original design of Mr. Caldwell, who for some two years past has been experimenting with a view to the imbedding, cutting, and mounting of sections with greater accuracy and much greater rapidity than has been done heretofore. By all the existing methods each section is cut and transferred to the slide separately. Besides the great waste of time involved in this process, it is impossible to get a uniformly thin series, owing to the contractions and expansions of the imbedding mass through the thickness of several sections. Mr. Caldwell found a way some time since of making sections adhere to each other as they are cut, so as to form a flat ribbon of consecutive sections, and to this end he designed the original microtome on which the present pattern is based. Information as to the methods of imbedding, cutting, and mounting will be published in an early number of the Quarterly Journal of Microscopical Science.'

The illustration, although taken from a catalogue published a little later, shows one of these instruments.

265. The Cambridge Rocking Microtome. 1885.

The first mention of this instrument appears in a catalogue of the Cambridge Scientific Instrument Company dated May 1885.

'The C.S.I. Company's own pattern for cutting sections by the ribbon method first suggested by Mr. Caldwell. It produces the same results as the original large pattern.

i.e. (Caldwell's Automatic Microtome). Instead of being taken up by the endless band, the ribbon of sections falls to the table by its own weight or the slide may be placed on the table and the sections will fall into position for mounting.'

It is the simplest, cheapest, and most generally efficient microtome that has ever been put into the hands of the biologist.

The illustration on p. 361 is taken from one of the catalogues published soon after the invention of the rocking microtome by Sir Horace Darwin.

266. Large Sliding Microtome.
By 'J. D. de Groot Utrecht'.

267. Sliding Microtome by Jung on iron base.

268. Three Microtome Razor-blades with slot fitting, marked respectively:

Real Old English Razor.
'Fulcher, Cambridge'.
'C. Franck'.

269. Schantzer Microtome. 1887.
Prof. Nuttall.

MICROSCOPES

270. Large Monocular Microscope.
By 'S. and B. Solomons, 39 Albemarle Street, London'.

271. Small Microscope with vertical motion only.
With nose-piece for four powers: small box containing five objectives, &c

272. Small Microscope with vertical motion only.
By *Hartnack succ. de G. Oberhaeuser Place Dauphine* 21, *Paris*. Box 'No. 5113'. A derivative of the drum type. Lens for illuminating opaque objects on jointed arm fixed to tube.

273. Microscope with inclined motion.
'Carl Zeiss, Jena, No. 4420.'
Nose-piece fitted for three powers.

Numbers 274 to 280 are engraved with the inscription *Francis Maitland Balfour, Morphological Laboratory*, 1882.

274. Student's Microscope, non-inclinable. 1875.

'1476 Carl Zeiss, Jena, 2409.'

Focusing screw below pillar. Used by F. M. B. as a freshman.

275. Inclinable Microscope. 1873.

By 'Carl Zeiss, Jena'.

Nose-piece for four powers.

276. Folding Microscope on three legs.

By Baker, London. Taken to Naples by F. M. B.

277. Folding Microscope.

Made specially for F. M. B. by 'C. Verick, Rue de la Parcheminerie, Paris'.

278. Student's Microscope. 1877.

By 'Carl Zeiss Jena, No. 2998'.

With revolving stage and microscope tube. Treble nose-piece.

279. Microscope. No. 7100. 1878–9.

By 'Carl Zeiss, Jena'.

This instrument was used for most of F. M. B.'s researches, and like the last has a revolving stage and microscope tube.

280. Large Zeiss Microscope. No. 8295. 1881.

A gift to Balfour from his relations.

281–291. Objectives. c. 1882.

Various powers, in wooden box with engraved brass plate.

292. Balfour's Dissecting Microscope. c. 1882.

By 'R. & J. Beck, London & Philadelphia. 8822'.

Round brass base, one pillar; black stand; one lens on jointed arm; mirror.

293. **Two brass 'right-angles'.**

Adam Sedgwick inherited Francis Balfour's instruments on behalf of the Laboratory. Some of those not engraved with Balfour's name were probably obtained by Sedgwick, but these are difficult to identify with certainty: though there is a label in the case indicating instruments 'used by Profr. Adam Sedgwick'.

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294. **Dissecting Microscope.**

On brass horseshoe base. One column. Mirror. Lens arm not jointed.

295. **Dissecting Microscope.**

Supported by four brass pillars on wood base. Stage 7 in. square, 5 in. high. Mirror. High and low power lenses.

296. **Large Microscope to clamp to table.**

With tube fitted on brass pillar with screw-fitting. Property of Alfred Newton after 1866.

297. **Folding Microscope on three legs.**

Signed: 'Baker, 244 High Holborn, London'. Marked on stage 'J. S. Budgett'.

298. **Large Microscope.** No. 848.

By 'Smith & Beck, 6 Coleman St.'

299. **Large Microscope.**

By 'Powell & Lealand, 140 Euston Road'.

A second is in the School of Biochemistry.

300. **Stephenson's Binocular Dissecting Microscope.**

By 'J. Swift & Son, London'.

301. **Five hand lenses and holder** in cloth and wood case.

By 'C. A. Steinheil Söhne, München'.

302. **Prism reflector** with brass mounting, in box.

Another, virtually a duplicate.

303. **Wooden stand for lenses.**

XIV

BOTANY

TURNER, RAY, GREW, and HALES are names which will always be honoured in the history of Botany. Yet centuries before them, the lore and skill of Herbalists had been illustrated, treasured, and practised in at least one of the more important centres of culture in East Anglia. On the shelf or book-press M in the Abbey of Bury St. Edmunds stood a Latin version of the Herbal of Apuleius Barbarus of Madaura, in which not only were recorded the names, sources, and virtues of a large number of medicinal herbs, that had been carefully copied in the Abbey, but which was embellished with coloured drawings apparently made from living plants growing in or near the Abbey garden. Doubtless a manuscript of Dioscorides was there as well. Such storehouses of botanical and medical knowledge must have had a profound effect when in need, sickness, or other adversity human pain insistently called for alleviation by treatment with the appropriate botanical remedy. And we know that fevers and rheumatic inflictions were rife amongst the dwellers of the low-lying fenlands of Cambridgeshire.

Still, though local practitioners may have wrung valuable secrets from their native plants, the vast bulk of the botanic learning of the day came from overseas, and was largely unusable here by reason of its exotic nature. There was obvious need for someone to sift the true from the false, the useful from the dross. A member of Pembroke Hall made a first attempt in this direction.

WILLIAM TURNER, born at Morpeth in Northumberland between 1510 and 1515, came up to Pembroke Hall where


NEHEMIAH GREW, M.D.
SECRETARY TO THE ROYAL SOCIETY

he became a Fellow in 1531. Like many other early men of science, he had received his early education amid the stimulating turmoil of the church controversies of the Tudor period. In Turner's case heresy-searching may have served as training for exorcising superstition from scientific treatises, or it may have called for a rest-cure, such as that provided by steady application to the delightful study of plants. But anyhow by 1538 he had compiled a first little essay on English Plants—the *Libellus de re Herbaria novus*, now exceedingly rare, in which the locality of many of our native plants was printed for the first time.

Being yet a student of Pembroke Hall, whereas I could never learn one Greke, neither Latin, nor English name, even amongst the physicians, of any herbe or tree: such was the ignorance at that time; and as yet ther was no English Herbal, but one all full of unlearned cacographies and falsely learning of herbs.

While still at Cambridge he embraced the tenets of the Reformation, which brought trouble and unrest into his life, for his religious zeal impelled him to travel 'through a good part of England, and preach not only in towns but also in cities. In his rambles he settled for a time in Oxfordshire . . . purposely for the conversation of men and books'. After a term of imprisonment he was banished from England, and went to Italy, studying botany under Luca Ghini at Bologna and qualifying for the degree of doctor of medicine. After a few more years of religious controversy, he published his second botanical tract on *The names of herbes in Greke, Latin, English, Duch & Frenche wyth the commune names that Herbaries and Apotecaries use* in 1548. After his return to England he must have found considerable backing in high places, for he was offered the headship of two Oxford Colleges, Oriel and Magdalen; successful at neither, he was appointed Dean of Wells. The accession of Mary led to a second banishment, this time to Germany, where he obtained the wood-blocks to Fuchs' Herbal, and included them in his large Cologne-printed Herbal of 1562. Indeed, it may have been these very figures that induced him to write up the letterpress of the book. Turner's *Herbal* was published in three parts, in 1551, 1562, and 1568. It had the transcendent

merit of having been based upon, and tested by, the writer's own observation and experience of English plants, to many of which he gave names for the first time.

These prepared the way for a larger work for the illustration of which he was so fortunate as to be able to acquire upwards of 400 wood-blocks of the figures from the *Herbal* of Leonhart Fuchs. When Elizabeth came to the throne, he was reinstated at Wells. He died in Crutched Friars in London on 7 July 1568. By his wife Jane, daughter of George Ander, an alderman of Cambridge, he had a son PETER TURNER, M.D.

As he explained in the Prologue to his *Herbal*, he desired to act for the good of his country by declaring the virtues of every herbe, and showing the place 'where I have sene it, . . . in what place of England every herbe may be had and found in',—and in the English tongue. 'For these three years and an halfe', he tells us, 'I have had no more lyberty but bare iii wekes to bestowe upon ye sekyng of herbes.' In the writing this book he considers he has done better than all the learned men in England who have not published their knowledge. Among them he mentions Dr. Clement, Dr. Wendy, Dr. Owen, Dr. Wotton and Mr. Falconer. His chief justification for the use of English is that there were many apothecaries and surgeons who practised physic but who were ignorant of Latin. Consequently they are 'ignorant in herbes' and put many a good man in jeopardy of his life. Is it better that many men should be killed, or that the *Herbal* should be set out in English?

There can be no doubt that he started a new era in the study of plants in this country, in that he did all that he could to emancipate himself from what he called 'Pliny's Hearsay'.

Two other Cambridge men of the sixteenth century interested themselves in Botany. ANTHONY ASCHAM, who after eight years' study took the degree of M.D. 1540, and was then presented to the vicarage of Burneston in Yorkshire. He was the author of

A littel Herbal of the properties of Herbs, newly amended and corrected 1550.

WILLIAM MOUNT, *b.* Mortlake, Surrey, 1545, educ. Eton

and King's, fellow 1566–9; Master of the Savoy 1593/4–1598. Details as to his particular skill he left to posterity under the titles of:

1. *Directions for making distilled waters, compound and simple,* 1590. MS. Lansd. 65, art. 75.
2. *Description of the ingredients of a certain composition called Sage Water,* 1591. MS. Lansd. 68, art. 88.
3. Latin verses prefixed to L'Obels *Balsami, Opobalsami, Carpobalsami & Xylobalsami, cum suo Cortice explanatio.* 1598.

Mount lived at East Malling in 1581 and made the first considerable contribution to the flora of the county of Kent, with important notes upon the medicinal uses of the plants.[1] He died in 1602.

In the sixteenth century one or more Herbals were usually included in the libraries of medical men. John Soward of Clare owned Fuchs's *De natura stirpium* and Macer's *De virtutibus herbarum.* John Thomas (?1490–1545), who was licensed to practise surgery in 1513–14, had 'an herball in French' which was sold for 4*d.*; Dr. Richard Widdows's Herbal was in Latin; Dr. J. Hatcher (?1512–87), whose library included several books of value, owned a Dioscorides; Dr. Lorkyn (1528–91), Turner's *Herbal* 1568, valued at 5*s.*, and Tusser's *husbandrie*; Dr. Robert Pickering, who died in Dr. Hatcher's house in 1551, Brunfels's *Herbarium*, 3*s.* 9*d.*, and *Parvum herbarium.*

About 1588 when Sir Christopher Hatton was elected High Steward of the University as well as Chancellor of Oxford, John Gerard, the herbalist, applied for leave to lay out a botanic garden.

The draft of his letter is endorsed 'John Gerard. A lettre of his owne drawing for ye Lord Threasurer [Burghley] to signe for ye Vniversity of Cambridg for planting of gardens', but there is no evidence that it was ever received by the University.

After my most hartie commendations, etc. As yt hath beene alwaies myne especiall care (neither doubt I but it is yours also) to procure by all meanes possible ye floorishing estate of your Universitie in religioun and liberall sciences: so at this present

[1] Gunther, *Early British Botanists,* pp. 253–63.

(to my great comfort) I see yt not inferiour herein to any Universitie in Europe, or any other part of ye world, were yt not that many famous nurseries (as Padua, Montpellier, that of Vienna, and others,) had prevented, or rather provoked us by their good example, in purchasing of publique gardens, and seeking out men of good experience to dresse and keepe the same, wherby that noble science of physicke is made absolute, as having recovered the facultie of simpling a principall and materiall part thereof. Wherfore not doubting of your readines in imitating or emulating the best in so laudable actions, I thought yt good to moove yow herin, and to commend this bearer, Jhon Gerard, a servant of mine unto yow, who by reason of his travaile into farre countries, his great practise & long experience is throughly acquainted with the generall and speciall differences, names, properties & privie markes of thowsands of plants and trees. So that yf you intend a worke of such emolument to yourselves & all young students, I shall be glad to have nominated & furnished you with so expert an Herbarist, & yourselves will think well of the motion and the man. Thus desiring God to prosper all your godlie studies and painfull endevers, I bidde you hartely farewell.'

MS. Laud cvii, art. 92.

The Seventeenth Century

The great work of the seventeenth century was done by herborists who made forays even into the most remote and mountainous districts in their endeavour to thoroughly explore the English flora. And so far had the study of plants progressed, that in 1654 Barrow 'asserted that Cambridge freshmen could name and distinguish all plants that were to be found in the fields and gardens of the neighbourhood'. (*Works* (Napier), ix. 46.)

Be this as it may, the greatest Cambridge men of the century were John Ray and Isaac Newton, both of Trinity.

John Ray (1627–1704/5) did more to advance the scientific study of botany than anyone had ever done before. He arranged nearly 7,000 plants in a natural classification in which he suggested many of those groups or 'Natural Orders' of plants which are still accepted to-day. By his *Methodus Plantarum Nova*, 1682, he showed the true nature of buds, and established the fundamental distinctions

between Dicotyledons and Monocotyledons. In 1686–8 he published the first two volumes of his work, the great *History of Plants,* and in 1690 he brought up to date the first manual of systematic botany published in England, the *Catalogus Plantarum Angliae.* In all his work he maintained a correspondence with the other naturalists of his day and was always most scrupulous in acknowledging the help he may have received from them. In his own work he was 'the most accurate in observation, the most philosophical in contemplation, and the most faithful in description amongst all the botanists of our own or perhaps any other time.' (Sir J. E. Smith.)

Ray's classification was based on structural characters—notably on the nature of the fruit, the structure of seed and on vegetative habit. He was aware that the seed contains an embryo and also endosperm, which he called *medulla* or *pulpa.* Although not quite assured of the sexuality of plants, he declared that appearances were in favour of that theory, and later is said to have admitted that the stamens were male in character.

The enthusiasm with which Ray and his pupil-friends prosecuted their scientific studies is well illustrated by their correspondence with one another. The greater number of Ray's letters have been printed by the Ray Society, but a few which have not been previously printed have recently become available, and it is from them that the following letters and extracts have been taken.

In letters to Peter Courthope (1639–1724) of Trinity and of Danny Park in Sussex, written by Ray in 1661 and 1662, there are many references to their botanical interests and to events at Cambridge. The correspondence has been printed in part in *The Further Correspondence of John Ray* (Ray Society 1928) supplemented by an article in the *Journal of Botany* for August 1934.

In a letter, 'No. 6', dated from Trinity, July 1661, Ray gives the itinerary of his northern journey. The correct text should read as follows:

'My company is only Mr. Skippon and a servant; the utmost terme which we designe of our journey is Edinburgh; the time we intend to spend is at the most but six weeks, unless some

extraordinary accident impede or retard us. Our stages we have contrived to be Peterborough, Boston, Lincoln, Hull, Yorke, Knaresborough, Gisburgh, Durham, Newcastle, Alnwick, Barwick, Edinburgh. And we shall think of some other way to returne home by: possibly we may call upon Mr. Willughby.

'We have this year made a more narrow search into the countrey about Cambridge for plants, and have discovered in all about 26 that are not in our Catalogue—some such as I had not seen before, nor are mentioned to grow wild in England.'

The names and localities of the following species are there given:[1]

Carduus acanthoides
Ranunculus acris
*R. hirsutus**
*Carex pendula**
Hypericum hirsutum
Ruscus aculeatus
Cerastium viscosum
Solidago Virgaurea
Hieracium murorum
Blechnum boreale
Gnaphalium sylvaticum
Malva moschata
Herminium monorchis
Scabiosa Columbaria ?
*Galium tricorne**
Helleborus foetidus
Scolopendrium vulgare
Thymus Serpyllum and no doubt *T. ovatus*
*Limosella aquatica**
Fontinalis squarrosa
Lathyrus Nissolia
Calamintha Nepeta

In letter No. 9, dated 14 October 1661, there is a long disquisition on *Triglochin maritimum* and *T. palustre*.

To letter No. 14, dated 28 April 1662, the following passages can now be supplied. It was written from Cambridge and not from London as suggested.

Letter No. 14

Cambridge Aprill 28. 1662

Sr,

In my last I gave you an account of my safe arrival at London. I have since sent another to my pupill T. B[urrell]. acquainting him with what other passages I thought worth the relating. I then wrote not to you, because I imagined you were in Kent, & it would be late before my L^{r} should come to y^{r} hands. I am as yet at Cambridge, but intend upon

[1] The plants marked with asterisks are here named two years before the 'first records' assigned by W. A. Clarke.

Wednesday May 7th to set out for Middleton. I believe we shall have Mr. Skippons company, who hearing of our intended designe offered it: I know not whether it will be acceptable to Mr. Willughby or no. Since I came to Towne I wrote a Lr to Mr. Hunt but have as yet received no answer from him. I desire you would send me word whether you have made any enquiry about the free school at Lewis. [Since I returned . . . leaves. *Printed in Further Correspondence.*] I saw not Dr. Morrison when I was at London, he not being at home, but his plants I saw. There are indeed many, and those no vulgar ones. I was at Edw. Morgan's & took an exact survey of his garden: I promised him a Cambridge Catalogue, but now I must rely upon you for performance. I wrote something to T.B. about 2 Drs. of Physick who enquired for me at London, which to save me the trouble of repeating, I pray informe yrselfe of from him if so you list. I have heard no more since of them, but that they desire correspondence by Letter. [Our new Master . . . my visits. *Printed.*] This morning a great pillar of the church Dr. Martin, Master of Q[ueens] College died, to ye no small grief doubtlesse of that party. Other newes I know of none either in Town or Universitie, all things continue in statu quo. Your friends & acquaintance here are all well. Mr. Budgen is gone downe: I suppose to his fathers house. Mr. Lynnett presents his service to you, & intends to visit you when he goes into Sussex, which will certainly be, *bono cum Deo* this summer. Dr. Duport enquired of you, in reference especially to Dr. Brians debt for which you stand to him engaged. I wish Sir you would doe something in it speedily to his satisfaction if you can. I told him the money was sure & you responsible enough, but you know *Gratia ab officio quod mora tardat abest.* I pray present my service to all your honoured relations which are known to me, especially to the most honoured your mother. I have not room to add more than that I am Sr. Your most obliged Srt

J. Wray.

In No. 15 of May 1662 there is a considerable list of plants collected at Gamlingay (*Journ. Bot.* 1934) to which Ray notes that he had then found 40 species of local plants not in the Cambridge Catalogue.

In this letter he intimates his intending trip to the west

of England, which is further described in the following unpublished letter, which I may call '15 a', dated 24 July 1662:

Sr,

After a long perambulation I am now returned homewards as from London where I have stuck longer than at first I intended. I left Mr. Willughby about 5 weeks since at a little towne some 20 miles on this side Glocester; and in company with Mr. Skippon only rode on westward as farre as ye Lands end or utmost Cape of Cornwall. I shall not now trouble you with a tedious narration of this voyage. I may perhaps ere long have leisure enough to wait upon you again in Sussex, for I fear I shall now be necessitated wholly to dismisse my employment & renounce my interest at Trin. Coll. I have already taken so many oathes & subscriptions as have taught me to disgust such pills [for the future]. However I intend to goe downe to Cambridge ye next week to settle my affaires there, & see how sqares goe. Mr. Willughby is intent still upon his transmarine expedition & will I believe, solicite you for your company. I should be glad to goe over with him, but am shie of aggravating his charge which I must now be necessitated to doe or stay behind, if I doe not con this subscription, which I shall hardly prevail with my selfe to doe: & if I doe it will be certainly contrary to my inclinations & purely out of fear. I shall not take my leave without telling you that we coasted Wales round about from W. Chester to Chepstow, & then Mr. Skippon & myselfe the West of England also, spending in continuall travell about ten weeks, many memorable things we met with and received as much satisfaction as could be expected on such post hast as we were. I pray present my most humble service to ye much honoured your mother & other relations, & so I rest

Sr.

your most obliged servant

July 24 1662. Jo: Wray.

To this should follow letter No. 11 which was written from

Black Notley Aug. 13. 1662.

Sr.,

I wrote to you from London, I know not whether or no you received it. I am now in Essex, where I have been about

a fortnight, & where I intend to continue till Bartholomew day be past. I am as good as resolved not to subscribe the Declaration in the Act of Uniformity & so can expect no other than deprivation of my fellowship. I must stay hereabout to make up my accounts & to dispose of my goods till about Michaelmas. Many of our ministers heer in this County will be deprived upon this Act, & those too the most able and considerable. I should be glad, S^{r}, to receive a line or two from you, that I might know whether you intend to settle at Danny or no. I believe Mr. Willughby would be glad of your company to goe with him beyond sea. I know not whether he hath yet solicited you to that purpose or not. I shall now cast myselfe upon Providence and good friends. Liberty is a sweet thing. I am hampered enough already, indeed more than I would have been had I foreseen this. I have not heard from you or of you any way since I took my leave of you at Danny, & therefore if this comes to your hands, I must entreat you to write, & direct your letter to be left for me at the postmasters at the George in Witham in Essex, where I will enquire for it. This place being the nearest of the rode, & about five miles distant from the place where I now am. I shall expose myself to much trouble & many inconveniences by this refusall, but *Quicquid vel superanda omnis fortuna ferenda est.* I doubt not but I shall be some way or other sustained, & it may be more to my satisfaction then if I should swallow the Declaration & continue still in Trinity College.

I pray present my most humble service & thanks to the much honoured yr mother & my service to ye rest of yr honoured relations knowne to me. It remains that I tender you my most hearty thanks for yr many late & former favours & kindnesses & profess my deep sence of those ingenuous expressions & testimonies of love & good will you have alwaies shewn me, *instincto proprio, nullo meo merito,* wch I have very great reason highly to value & much to set by, & ever shall doe, *Dum memor ipse mei* etc & take my leave. I am Sr

Your most devoted servant & debter

Jo: Wray

Pardon this methodically confused writing, when I read it over, I could hardly refrain tearing it in pieces, but that I wanted time to write anon.

In this letter Ray was but reaffirming his resolution of two years earlier, when, writing to his Sussex friend Courthope in Sept. 1660 on the occasion of the readmission of new fellows at Trinity, he said: 'They were content to reserve my place in case I would promise conformity. . . . I have long since come to two resolutions, namely—No promise of conformity, and no orders. . . . They have brought all these things here as they were in 1641; viz. services morning and evening, surplice Sundayes and holydays, and their eves, organs, bowing, going bare, fasting nights' (Ray, *Further Correspondence*). In 1644 all Fellows of Peterhouse were ejected for refusing the Covenant, with the exception of Dr. Francis, a physician.

Ray's letter of August 13 was followed by Nos. 16 and 17 of August 28 and Sept. 4, both from Cambridge, and by Nos. 18 and 19 from Friston Hall on Nov. 3 and Jan. 20, 1662–3.

The former of these contains the famous description of the Sea Pea or *Lathyrus maritimus* of Aldburgh. Ray concludes that letter with the remark: 'I shall not be idle during my abode in this Countrey but gather up all the observations I can meet with I believe I might adde to my stock of wild English plants were I here in Somer time, wch I cannot hope to be. I rest Sr. Yours in all service most devoted Jo. Wray.

My most humble service to ye much honoured yr Mother & other relations.'

The two remaining letters dated from Friston 16 Feb. 1662 and Black Notley 19 March 1662, 'No. 12', obviously belong to the following year 1662–3 and are not to be taken in the order in which they appear in the *Further Correspondence.*

These for the Wor^{pfull} Peter Courthope Esq^{r} at Danny in Hurst per point near Lewis in Sussex.

Post p^{d} to London.

Black Notley March 19 1662

Sr,

I wrote a Letter to you to London wch I feare is lost because since I received no answer. I have now left Friston Hall, & am come to Black Notley in Essex, that I may settle my

affairs and prepare for my journey. By the latter end of the next week I hope to be at London, & to meet Mr. Willughby there. It is now no time to deferre. In my last I acquainted you with my designe of putting out a sheet of *Addenda & emendanda* to our Cambridge catalogue desiring your judgement: & that you would please to communicate such *errata* as you may haply have observed. I now again renew the same request to you, though I feare they will come too late. I should be very glad to see you S^r^ before we goe, but unlesse you have occasions at London about that time I suspect it will hardly be; we are like to be in great haste. Your countryman Mr. Carre is settled our neighbour heer at Braintree, I have not yet seen him. Indeed I came hither this very day. The living is but small. I believe *vijs et modis* not worth one hundred per year: but he hath a great auditory, it being a large market towne. I hear he finds very good acceptance there; only some like not well that he is so punctuall in reading all the common prayer: I am told that the Bp. of London hath bound him in a great summe of money to read it all himselfe once a month as the Act for Uniformity requires. I should be glad to hear from you but I cannot contrive how or whither you might send a L^r^ that would certainly find me. My prayers and good wishes shall alway attend you, & whereever I am I shall glory in the title of Sr

Your most devoted servant

John Wray.

The relative seniority of John Ray and his contemporaries at Trinity is stated by the following entries in the Admissions Register.

Wm. Croyden. Fellow 1640. Tutor 1646. Sen. Burser 1647–50.

Wm. Disney. Fellow 1645. Tutor 1646–52. Vice-master 1654–5.

John Nidd of Kent. Sizar 1640. Fellow 1647. Tutor 1650–5. Dean 1657–8.

Wm. Linnett of Sussex. Sizar 1641. Fellow 1647. Vice-master 1691–1700.

John Wray, from St. Catharine's Hall. Subsizar 1646 (tutor Mr. Duport). Fellow 1649. Tutor 1653–1660.

Thos Pockley. Subsizar 1645–6. Fellow 1650. Tutor 1661.
John Mappletoft of Essex. Pensioner 1648. Fellow 1653. M.D. 1667.
Francis Willughby from St. John's. Fellow commoner 1652. M.A. 1659.
✓ Peter Courthope. Fellow commoner 1655. Did not graduate.

John Ray's Official College Pupils

✓ Philip Skippon. Fellow commoner 1655. Did not graduate.
Timothy Burrell. Pensioner 1652. Matric. 1659. B.A. 1662–3.
Thomas Colville. Pensioner 1659. No degree.
Joseph Coney. Subsizar 1659. Matric. 1661. B.A. 1663–4.
Matthew Bouchert. Pensioner 1659–60. Matric. 1660. Fellow 1664.
Henry German. Pensioner 1660. No degree.
John Allen. Sizar 1660. Matric. 1660. M.A. 1669.
Edw. Goring. Fellow commoner 1660. No record of matric. or degree.
Robert Grace. Sizar 1660. M.A. 1668.
Job Grace. Sizar 1660. M.A. 1668.

Afterwards appears the entry:

Isaac Newton. Subsizar 1661. Tutor Mr. Pulleyn. Matric. 1661. B.A. 1664–5. Fellow 1667. Tutor 1669–87.

The Masters of the College during this period were:

John Arrowsmith	1653–9
John Wilkins	1659–60
Henry Ferne	1660–2
Isaac Barrow	1673–7

The movements of plants and the ascent of sap presented physiological problems of special interest to Ray, who continued the early studies which he had made with Francis Willughby on the bleeding of freshly cut stems and roots of the birch and the sycamore.

What Ray achieved for the System of Plants, Nehemiah Grew, matric. Pembroke 1659, *d.* 1712, did for their minute structure. He had practised medicine at Coventry, but about 1672 removed to London, became acquainted with the virtuosi of the Royal Society, into which he was

elected a fellow in 1671, and doubtless through which he got into emulatory correspondence with Malpighi. In 1677–9 he was co-secretary with Hooke.

His more important discoveries are described with excellent engravings in the *Anatomy of Plants* 1684, which includes the *Anatomy of Vegetables Begun*, and also the anatomy of roots and of trunks and the anatomy of leaves, flowers, fruits, and seeds.

He was the first to describe adequately the resin passages and medullary rays in a pine tree. He noted that the members of successive whorls in flowers are arranged alternately, and that flowers are sexual, although he did not recognize the true significance of pollen. He perceived that there were openings or stomata upon the leaves, and suggested that they were 'for the better avulation of superfluous sap or for the admission of air'. The ascent of sap he explained by capillary attraction.

His detailed description of a bean-seed is worthy of all praise. After noting the cotyledons, he recognizes that the foramen 'is not a hole casually made, or by the breaking off of the stalk; but designedly formed for the uses hereafter mentioned'. Thus when squeezed, a bean seed gives rise to many small bubbles through 'the foramen'. He distinguished radicle, plumule, and the two cotyledons, which he called 'dissimilar leaves' having among other peculiarities a *parenchyma* (word coined by him) consisting of an infinite number of tiny 'bladders'. When such rows of 'bladders' occur piled perpendicularly one above the other, their interiors may unite to form a 'continued cavity'.

On turning to the physiological aspect of Grew's work we find that he realized that the green colour of leaves is due to exposure to the air, but not that exposure to light was also necessary. Knowing that certain vegetable juices turn green when an alkali is added to them, he assumed that leaf-green was also due to some alkaline property of air.

On the whole he shares the honour with Malpighi of having founded the science of Vegetable Anatomy. He relied more on morphological rather than on physiological evidence, and but rarely tested his assertions by experi-

ment; so that in this respect he fell far short of his successor, Hales.

Matthew Robinson, fellow of St. John's, 1650, was a distinguished horse-breeder and a keen botanist. [Mayor, *M. Robinson*, pp. 31, 106.]

Adam Buddle took his degree at St. Catharine's Hall in 1681, where he held a fellowship 1686–91. Uffenbach saw his collection (*Reise*, iii. 202). He died 1715.

Tancred Robinson, M.D. (St. John's). Account of the Tubera terrae or Truffles, found in Northamptonshire, Lycoperdon tuber L. *Philosophical Transactions*, 1693.

Not all students of botany attended instructional courses. Abraham de la Pryme recorded that 'In this my freshman's year [1690], by my own proper studdy, labour and industry, I got the knowledge of all herbs, trees and simples, without any body's instruction or help, except that of herbals; so that I could know any herb at first sight'.

William Vernon was even granted permission by the Visitor of Peterhouse 'to be absent for three or four years to improve his Botanick Studies in the West Indies', with the proviso that he shall certify yearly that he is alive and unmarried (23 December 1697). Vernon collected plants in Maryland.

The idea of travelling fellowships was not a novelty at Cambridge, for Fynes Morison of Peterhouse had held one in 1589.

The Eighteenth Century

As the sixteenth was the century of Turner and the seventeenth the century of Ray, so the eighteenth must be regarded as the century of Stephen Hales, the Father of Plant Physiology. His academic distinctions have been briefly set out on p. 314.

The greater part of Hales's work was done at Teddington, where with simple means he achieved results of the highest scientific value.

An interesting account of some of his early interests is given in the Diary of his friend Stukeley. When in 1704 Stukeley turned his mind to the study of Physick he 'began to make a diligent & near inquisition into Anatomy

and Botany, in consort with Hobart, a senior lad of Benet College . . . with him I went frequently a simpling'. With him and others that study'd Physic 'I used to range about once or twice a week the circumjacent country, and search the Gravel & Chalk pits for fossils. Gogmagog hills, the Moors about Cherry Hinton, Grantchester, Trumpington, Madingley Woods, Hill of Health, Chesterton, Barnwell were the frequent scenes of our simpling toyl, armed with candleboxes & Ray's *Catalogus*' [*Plantarum circa Cantabrigiam nascentium*].

About 1706, George Rolfe, prof. of Anatomy 1707–28, 'was very curious too in the knowledge of Botanics. Mr. Step. Hales, & he & I & Mr. Sherwin, Fellow of Christ's, & several more of us, us'd to go a simpling together. I had drawn a Map of the County of Cambridge to put into Ray's Catalogus which I carried about with me. (Pl. III.) They put me upon dressing up a new Edition of that famous Restorer of Botany among us, whereto should have been prefixed a Map, & they would procure the large Additions to the work of plants observd there since his time, but my short stay there prevented any such thoughts being put in execution.'—(Stukeley's *Diary*.)

Vegetable Physiology

Grew of the Royal Society (1628–71) and Malpighi (1628–94) had applied magnifying glasses to the study of plant tissues, and Malpighi had concluded that the nutrition of a plant depended upon the leaves, while nutrient sap was conducted by the fibres of the wood, much as liquids will ascend in capillary glass vessels. But the continuous upward flow of sap was a mystery.

In 1718 Hales informed the President of the Royal Society that he had lately made a new experiment upon the Effect of ye Sun's warmth in raising ye Sap in Trees.

His method was the quantitative one of weighing a sunflower planted in a pot, every night and morning for a fortnight, having covered the surface of the soil with lead, so that all loss of weight by 'perspiration' must have been due to loss of water through the leaves. This he found to amount to 34 cubic inches in twelve hours. Then by cutting off all the leaves and measuring their total surface

area, by estimating the surface area of the roots and the cross-section of the stem, it became a matter of calculation to determine the actual velocity of the sap-flow in leaves, roots, and stem respectively.

He then collected comparable figures for other plants and compared them with the average perspiration rate of a man as determined by Dr. Keill.

Perspiration of water per square inch of leaf or body-surface in twelve hours.

Lemon Tree	1/248 cubic inches.
Vine	1/191
Sunflower	1/165
Apple Tree	1/102
Cabbage	1/80
Man	1/50

Vegetable Statics, 4th ed., p. 21.

Thus evergreens perspire much less than the deciduous plants, and

'so are better able to survive the winter's cold, because they want proportionately but a very small supply of fresh nourishment to support them; like the exanguous tribe of animals, frogs, toads, tortoises, serpents, insects etc. which, as they perspire little, so do they live the whole winter without food. And this I find hold true in 12 other different sorts of evergreens, on which I have made experiments.'

Hales showed that the liberation of vapour from the surface of a leaf is far less than that from an equal area of the surface of water, but had no idea of the mechanism by which the evaporation is checked. Here a definite advance was made when von Mohl recognized the guard-cells to be the controlling agents.

Having arrived at a rough estimate of the quantity of sap that flowed through various plants, he next turned his attention to the forces that might cause sap-flow. Malpighi and Grew had suggested the capillarity of the fibres in the wood, but that would not explain the continuous current through the plant, dependent on temperature and humidity. For this the additional assumption of *transpiration* by the leaves appeared necessary, and to test this Hales devised several experiments.

Transpiration, Sap-flow and Root-Pressure.

1. Two nearly similar branches were cut from a tree. The leaves having been removed from one, both were set in two vessels containing known quantities of water. The foliage branch took up 15 to 30 ounces of water during the night: the bare branches only took up an ounce. Thus the leaves determine the amount of sap that flows in a given time.

2. By a similar experiment he proved that two leaves imbibe and perspire as much as one apple.

3. The leafy branch of an apple tree to the stem of which a 9 ft. glass tube had been tied was immersed under water and the glass tube filled with water. After twelve hours the level of the water had dropped 6 in. The branch was then exposed to the air and the level of the water in the vertical tube fell 26 inches in 12 hours. This 'shows the great power of perspiration; since when the branch was immersed in the vessel of water, the 7 feet column of water in the tube above the surface of the water, could drive very little thro' the leaves till the branch was exposed to the open air.'

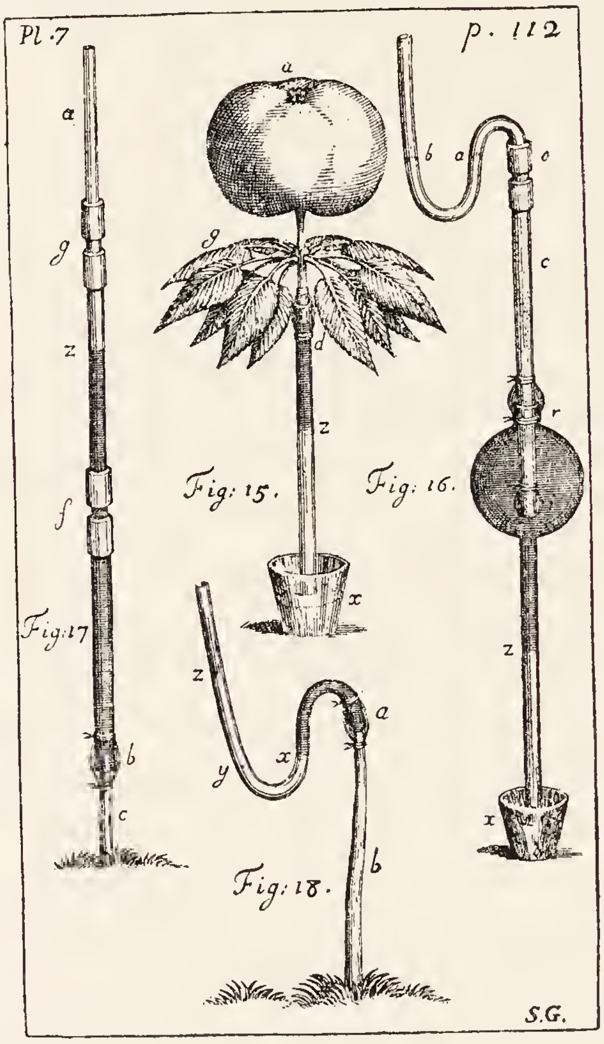
4. A leafy branch with long tube attached was turned upside down and the vertical tube filled with water. The level of the water fell rapidly. He then cut through the main stem above the leaves and set the foliage-bearing part upright in a vessel of water. The short leafless part of the stem was left with the hydrostatic pressure of the water in the tube above it. Notwithstanding a 7 ft. pressure only caused 6 oz. to filter through, while the leafy branch imbibed 18 oz. of water.

By further experiments he proved that 'though the capillary sap-vessels imbibe moisture plentifully; yet they had little power to protrude it farther without the assistance of the perspiring leaves, which do greatly promote its progress'.

'To find out the force with which trees imbibe moisture,' he tells us that his old haemastatical experiments on dogs had suggested some similar investigations on vegetables, 'but despaired of ever effecting it, till about seven years since [1720?] by mere accident I hit upon it, while I was endeavouring by several ways to stop the bleeding of an old stem of a vine, which was cut too near the bleeding season, which I feared might kill it. Having . . . tied a piece

of bladder over the transverse cut of the stem, I found the force of the sap did greatly extend the bladder.' And to measure it he connected on a mercurial manometer as shown in 'Fig. 18'. And in the case of a large leafy branch of golden Pippin in the sunshine and in warm weather, he was able to record a pressure of 11 inches of mercury.

A further result was that he was able to disprove the



theory of circulation of Sap, comparable to the Circulation in Animals, for he showed that branches would 'strongly imbibe from the small end immersed in water to the great end, as well as from the great end immersed in water to the small end.'

Finally, in addition to the passive rise of sap in the vessels due to capillarity, and to the continuous flow of sap due to transpiration from the leaves, he demonstrated and measured a third force, *root pressure*.

The experiment is figured on 'plate VII, fig. 17'. To a vine stem, cut 7 inches from the ground, was tied a vertical glass tube to contain the extruded sap, with the result

that the sap continued rising daily until it stood 21 feet high, and might have gone higher but for a leaky joint.

To confirm this remarkable observation he substituted a U-tube mercurial manometer, and recorded the enormous pressure of $32\frac{1}{2}$ inches of mercury, equivalent to 43 feet of water!

'This force is near five times greater than the force of the blood in the great crural artery of a horse' he observed: it argues 'considerable energy in the root to push up the sap in the bleeding season'. At the same time he fully realized that two factors might be operating simultaneously; that one branch might have its sap-flow caused by pushing-up by root pressure, while another might be imbibing; and at another time the two processes might be reversed. He found this actually to happen in late summer, when there was no evidence of root-pressed sap, a large quantity of rising sap being supplied by capillary action to replace that which is perspired from the leaves.

This most important research was started in 1718, and seven years later, on January 14th, he communicated a Treatise concerning the Power of Vegetation to the Royal Society.

The most striking testimonial to the lasting value of Hales's work is to be found in the confirmation by the great German Physiologist, Julius von Sachs, who 'had to go back one hundred and forty years to Hales's experiment on transpiration to find results that he could compare with his own'.[1] Notwithstanding his complete ignorance of the chemistry of the fluids and gases involved, Stephen Hales by his cleverly combined and skilfully managed experiments compelled plants to speak for themselves, to disclose the forces that were at work in them by effects made apparent to the naked eye . . . 'Hales is the last of the great naturalists who laid the foundations of Vegetable Physiology.'

Growth of Plants

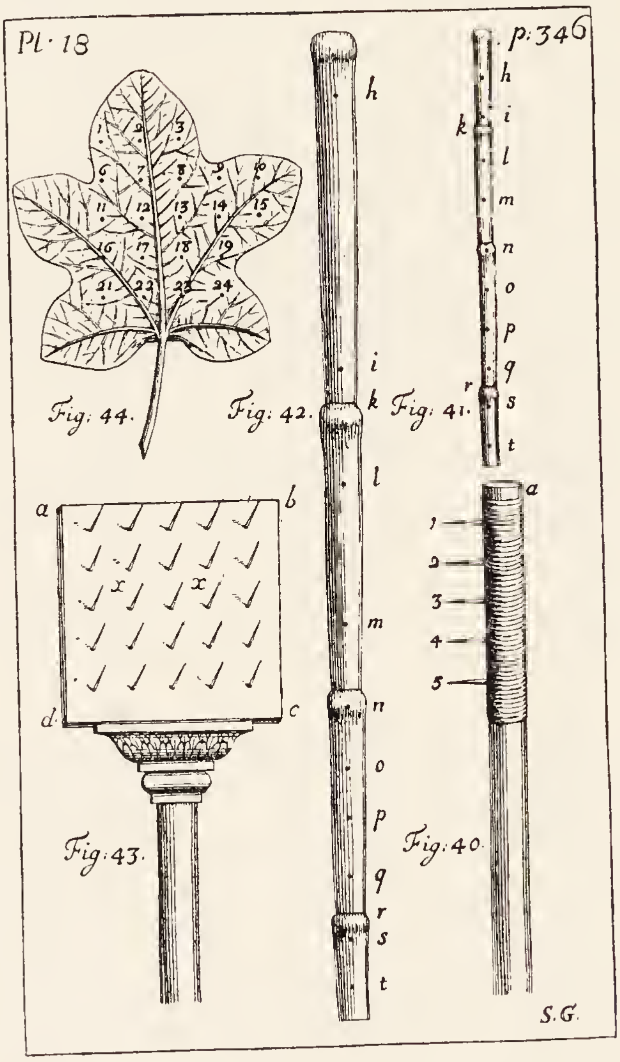
The experiment devised by Hales to study the growth of plants was to mark the young shoots and leaves of a vine with rows of points at $\frac{1}{4}$-inch intervals. This he did with

[1] Sachs, *History of Botany*, Oxford, 1890.

an emulsion of red lead and oil applied by a marking tool made by driving five pins in line through a piece of wood at equal intervals of $\frac{1}{4}$ inch. 'Fig. 40.'

In the following autumn the marks on the vine were still visible, 'fig. 42'.

'I found in them all a gradual scale of unequal extensions, those parts extending most which were tenderest. The whole



progress of the first joint is very short in comparison of the other joints, because at first setting out its leaves being very small, and the season yet cooler than afterwards, 'tis probable that but little sap is conveyed to it; and therefore it extending but slowly, its fibres are in the meantime grown tough and hard, before it can arrive to any considerable length. But as the season advances, and the leaves inlarge, greater plenty of nourishment being thereby conveyed, the second joint grows longer than the first, and the third and fourth still on gradually longer than the preceding; these do therefore, in equal times, make greater advances than the former.'

Vegetable Statics, 4th ed., p. 335.

Thus he settled the rule of relative growth. To verify Borelli's idea that the mechanical force of growth was due to 'turgescence', the imbibition of water by the cells of the plant, Hales filled an iron pot with dried peas and covered them with a lid on which he placed a weight of 200 pounds. When water was poured over them the peas swelled up and the force of their expansion lifted the weight. This vast force, he added, 'is doubtless a considerable part of the same force which is exerted not only in pushing the plume upwards in the air, but also in enabling the first shooting radicle of the pea, and all its subsequent tender fibres, to penetrate and shoot into the earth.'

Dry pith will not grow; so growth in length can only occur in the moist, tender shoots, and 'the wetter the season, the longer and larger shoots do vegetables usually make'.

Plant Nutrition

So long as men believed with Aristotle that the food of plants was elaborated out of the plant in the earth, no real advance was possible.

However, Mariotte in 1679 had shown that plants do manufacture new materials from those which they derive from the soil in which they grow.

Malpighi of Bologna came to the conclusion that these changes of food materials must take place in the green leaves, and that the nutrient sap must be conveyed from one part of the plant to another by the fibres of the wood. Malpighi communicated his views to the Royal Society, where they were adopted and again published by Nehemiah Grew, and were of course familiar to Hales, who set about devising experiments to test them.

In his first experiment on a bleeding vine, he noticed 'a continuous series of air bubbles constantly ascending from the stem through the sap in the tube, in so great plenty as to make a large froth at the top of the sap'. Conceiving the plant's sole intake for air to be in the roots, he cemented the stems of branches into closed vessels of air fitted with water-gauges, and demonstrated that air

was drawn up through the plant as water 'perspired' off from the leaves.

Secondly, he distilled, fermented, or acted on with acids, a number of substances with the view of preparing gases and of measuring the volume of gas evolved. From this the weight of the gas was calculated and expressed as a fraction of the weight of the substance from which it had been derived. In these experiments he introduced the method of collection over water into chemistry. Cf. p. 238. The value of his results must, of course, have been diminished by his not having taken into account the matter of solution in the water over which they were collected. Among the 'distilled airs' that he prepared, he found that that from peas 'flashed' and from 'Newcastle coal' killed a sparrow; but he did not otherwise distinguish between the various gases, such as hydrogen, carbon dioxide, sulphur dioxide, ammonia, all of which he must have prepared.

He was not in fact awake to the possibility of qualitative differences between his 'distilled airs'. He had his mind fixed upon the fact that gas could exist as part of a solid substance, and that its quantity could be measured and expressed as a fraction of the weight of the solid. And these proportions as determined by experiment he expressed in a table. *Vegetable Statics*, p. 98.

He concluded that by the amphibious property of air, viz. to exist either in an 'elastic' or gaseous state, or in a 'fixed' or solid state, 'that the main and principal operations of nature are carried out'; and in particular that solid vegetable substances contain air.

His third achievement was to demonstrate that plants actually have the power to 'fix' air in a solid form in the course of their growth.

'June 29th, I set a well-rooted plant of *pepper-mint* in a glass cistern full of earth, and then poured in as much water as it would contain: over this glass cistern I placed an inverted glass. At the same time also I placed in this same manner another inverted glass of equal size with the former, but without any plant under it: the capacity of these vessels above the water was equal to 49 cubick inches. In a month's time the

mint had made several weak slender shoots, and many small hairy roots shot out at the joints that were above water; half the leaves of the old stem were now dead; but the leaves and stem of the young shoots continued green most part of the following winter: the water in the two inverted glasses rose and fell, as it was either affected by the different weight of the atmosphere, or by the dilatation or contraction of the air inside (*with temperature*). But the water in the vessel in which the *pepper-mint* stood, rose so much above the surface of the water in the other vessel, that one-seventh part of that air must have been reduced to a fixed state, by being imbibed into the substance of the plant. This was chiefly done in the two or three summer months; for after that no more air was absorbed. The beginning of April in the following spring, I took out the old *mint*, and put a fresh plant in its place, to try if it would absorb any more of the air; but it faded in four or five days. Yet a fresh plant put into the other glass, whose air had been confined for nine months, lived near a month, almost as long as another plant did in fresh confined air; for I have found that a tender plant confined in this manner in April, would not live so long, as a stronger grown plant, put in in June. The like plants placed in the same manner separately, in the distilled airs of *tartar* and Newcastle *coal*, soon faded; yet a like plant confined in three pints of air, a quart of which was distilled from an ox's tooth, grew about two inches in height, and had some green leaves on it, after six or seven weeks' confinement.

(*Vegetable Statics*, 4th ed., p. 329.)

'We may reasonably conclude that one great use of leaves is to perform in some measure the same office for the support of vegetable life, that the lungs of animals do for the support of animal life; plants very probably drawing through their leaves some part of their nourishment from the air.'

Malpighi had held that plants drew in air by the roots. It is to the lasting glory of Hales that he was the first to recognize that plants breathe in air by their leaves, and fix it in a solid form in their bodies.

A wonderful prevision of his genius was his further suggestion 'May not light also, by freely entering the expanded

surfaces of leaves and flowers, contribute much to the ennobling principles of vegetables?' *Veg. Statics*, 4th ed.

Hales died at Teddington in 1761.

Dr. Woodward (see p. 431) was reported in 1710 to have had

Further, an elegant *herbarium vivum Anglicanum* collected by him, where the plants were extraordinarily fresh and well preserved. In another room in a lacquered cabinet he had a tolerable collection of all manner of Shells, where we saw one vastly curious thing, namely the Muscovy Vegetable Sheep, which is described in detail by Adam Olearius in his book of travels. It was not quite a span high, light brown, and the wool did not so much resemble ordinary long wool as the fibre that grow in a reed, though they are somewhat more woolly and have longer hair, as you might say; this plant takes nourishment through the feet that it has in place of roots. This was one of the greatest curiosities that we saw here, or, indeed, in the whole of our travels.

Dr. Woodward showed us all his things with such affected gestures and rolling eyes that we could not restrain our laughter, although he dislikes this quite as much as being interrupted; indeed he requires every one to hang on his words like an oracle, assenting to and extolling everything. (*Uffen bach.*)

Let us now return to the Cambridge of 1727.

The Professorship of Botany was being held by Richard Bradley, chosen in 1724 on the understanding that he would procure a public Botanic Garden for the University. The garden and his lectures alike failed to materialize, and the way was open for a more energetic teacher.

John Martyn, 1699–1768, F.R.S., had received his initiation into the study of Botany from John Wilmer, apothecary, and from Dr. Patrick Blair, F.R.S., and from 1730 onwards resided at Chelsea, where he taught as reader in the Chelsea Garden.

While serving as a London counting-house clerk he used to herbarize in St. George's Fields. His enthusiasm commended him to Dr. Sherard and Sir Hans Sloane as a competent botanist, and on their recommendation he was invited to lecture in Cambridge. Accordingly in 1727 in the

Anatomy Schools he gave the first course that ever had been read there in that science, with a view to restore this study on the spot which would seem most adapted to its growth, as having nourished the most eminent of all our English Naturalists, the eminent Mr. Ray. (Gorham's *Memoirs of the Martyns*, pp. 31, 2–113. Cooper, *Annals*, iv. 185.)

Martyn entered Emmanuel in 1730, and took part in several conferences about the projected physick garden, but owing to delay the proposed ground (Brownell's) was secured for another purpose. On 5 November 1732 Professor Bradley died, and in the following year Martyn was elected professor in his place.

The money value of the post at that time may be estimated from the fact that the University, in a petition against a bill to restrain the disposition of lands, pointed out that the Professors of Botany, Anatomy, and Chymistry have 'no endowment at all' (25 March 1736). Martyn's courses were on Materia Medica as well as on Botany, and he communicated several papers to the Royal Society. His historic tastes led him to turn his attention to the Botany of the ancients, and to publish fine illustrated editions of the *Georgicks* (1741) and the *Bucolicks* (1749) of Virgil, the former being dedicated to Mead. His contributions to the *Philosophical Transactions* included a description of his *Journey to the Peak*, of a *Purgative Water at Dulwich*, and of the *Aurora visible at Chelsea*. He also maintained a correspondence with Linnaeus. Some of his letters are preserved in the British Museum.

In 1762 he resigned the chair, leaving a valuable botanical library of twelve hundred volumes, and a *Hortus siccus* of foreign plants to the University. In 1768 he died and was buried at Chelsea.

In his old age Hales was again taking interest in Botany. We find him writing to John Ellis in February 1752.

I carried the collection of red Sea-mosses, which you sent me, to the excellent Princess [Augusta, sister of Geo. III] for which she was thankful and well pleased. And this day I showed her the method of spreading them, which she soon practised herself and liked very much; my nephew Sir T. Hales having

got me a few mosses from Dover. But pray let me know how you glue them on with gum arabic. I guess you wet the paper with it after the mosses are laid in their places dry. As the Princess designs to put several ladies on this agreeable amusement, it will be well to furnish her with plenty of these mosses.

Sir James Edward Smith. *A Selection of the Correspondence of Linnaeus and other Naturalists*, ii, London 1821.

Among other persons interested in the science at this time were:

Israel Lyons, born at Cambridge in 1739, the son of a Polish Jew of the same name, who had a great aptitude for mathematics. In 1755 he began to study Botany and collected much material for a 'Flora Cantabrigiensis'. In 1758 he published a Treatise on Fluxions. In 1763 *Fasciculus Plantarum circa Cantabrigiam nascentium quae post Raium observatae fuere.* In 1764 he was taken to Oxford by Sir Joseph Banks when he found that no one there would, or could, lecture on botany to students.

Benjamin Stillingfleet, author of *Calendar of Flora* (1761) and *Miscellaneous Tracts* by members of Upsala University, translated from Latin, was one of the first (in 1757) to bring the System of Linnaeus to the notice of Englishmen.[1] The favourite pursuits of the Rev. James Lambert, professor of Greek (Trinity) were fly-fishing and botany. (Gunning, *Reminisc.* ii. ch. iv.)

John Martyn was succeeded in 1762 by his eldest son, Thomas Martyn (1735–1825), 5th sen. opt. Emmanuel 1756, tutor of Sidney (1760–74), F.R.S. 1786, F.L.S. 1788. In the year after his appointment Dr. Richard Walker, Vice-master of Trinity, purchased the site of the old monastery of Austin Friars, for £1,600 for the Botanic Garden, to which were appointed T. Martyn, as first Reader, and Charles Miller, son of Philip Miller of the Chelsea garden, as first Curator. A considerable amount of planting had already been done, and a greenhouse was partially erected (1761).

T. Martyn had previously been a follower of Ray, but about 1752–3 made a close study of the *Philosophia Botanica* and the *Species Plantarum*, which so convinced

[1] Boswell, *Johnson*, 1781; Nichols, *Lit. Anecdotes*, ii. 335.

The Revd. THOMAS MARTYN, B.D. F.R.S.
Regius Profefsor of Botany in the University of Cambridge

him of the value of the system of Linnaeus, that he introduced it into his first lecture in 1763, contemporaneously with Professor Hope in Edinburgh. He failed, however, to make systematic Botany a popular subject in Cambridge. His lectures were uninspired: his class fell away and by the end of three years he had 'but few pupils, and those inattentive'. Also the garden-curator, C. Miller, left for the East Indies in 1770, and the professor gratuitously supplied his place, receiving (until 1793) nothing but his lecture-fees. Soon after he married the sister of the Master of Emmanuel and took the incumbency of Triplow, but continued to lecture to thin audiences; and in 1782 he was forced to include natural history and geology in his course in order to secure an adequate attendance.

After moving to London in 1784 he translated and continued Rousseau's *Letters on the Elements of Botany*, his most popular work, which went through eight editions; he also began his edition of Philip Miller's *Gardener's Dictionary*, but this was not published as a whole until 1807 in 4 vols. folio.

One would-be pupil, C. [Manners] Sutton, was helped in his studies in 1777 by a travelling studentship under W. Wort's will of 1709. *Descriptions of five British species of Orobanche*, Linn. Soc. 1797, was one result. Seven years later he became Archbishop of Canterbury.

In 1793 Martyn's Professorship was made a Royal one, and he was given a pension of £100 a year.

The refectory of the ancient Convent of the Austin Friars was being used as a lecture room by the Professor of Botany until 1789, but it was pulled down before 1808 (Lysons). A Lecture Room was built for the Botanical and Jacksonian Professors by a syndicate appointed in May 1784, and there in 1802 Martyn, or his deputy Richard Relham of Trinity, lectured during the first half of Midsummer Term at 4 p.m.,[1] the subjects being the Elements of Botany, and the Linnaean System. 'The doctrine of the Sexes in Plants, the foundation of that system, was proved: Physiology of Plants was explained, and the more curious and useful species were exhibited.'

T. Martyn's later work included the compilation of a

[1] *Univ. Calendar*, 1802.

List of Plants of Surrey for Manning and Bray's *History of Surrey* 1814. His letters to his friends were always full of plans for the future or of excuses for his shortcomings, with occasional excursions into mineralogy and geology. One of his remarks is worth recording, as a prophecy that came true:

'Will it not be remarkable if Cambridgeshire should have *four* Floras, before Oxfordshire has *one*?' (*Letter* of T. Martyn to Dr. Pulteney, 1783.) They were Ray's in 1660; Prof. John Martyn's in 1727; Prof. Thomas Martyn's in 1763, and Relhan's in 1785. Sibthorpe's *Flora Oxoniensis* was not published until 1794. (Gorham.)

During his last years Martyn lent his lecture-room to E. D. Clarke for mineralogical lectures. In 1818, feeling the effects of old age, he had endeavoured to procure Sir James E. Smith, M.D., first President of the Linnean Society, as his deputy, but this aroused the opposition of eighteen tutors of Colleges, except Queens', Clare Hall, Benet, Magdalene, and Downing, who, headed by Prof. J. H. Monk, refused to allow their pupils to attend the lectures of Smith who was a member neither of the University nor of the Church of England. Smith withdrew. Four pamphlets were published in the controversy:

1. Considerations respecting Cambridge, more particularly relating to its Botanical Professorship. Sir J. E. Smith, M.D., F.R.S. London 1818.
2. A Vindication of the University of Cambridge. By the Rev. J. H. Monk.
3. A Defence of the Church and Universities of England, against such injurious advocates as Professor Monk. By Sir J. E. Smith.
4. Appendix to a vindication of the University. By J. H. Monk.

Apropos of his candidature, Sir J. E. Smith received the following letter from his friend Samuel Goodenough, Bishop of Carlisle. It was dated 9 Oct. 1813.

My dear Sir,

I had heard from other quarters that you was making a push at Cambridge. I know no Cambridge people but who are your friends already, Davies & Young of Trinity, Holme of Peter-

house your advocate, and our Dean. I have spoken to him upon the subject & I hope convinced him that your science ought to beat down all barriers of doubt & difficulty & Academic Etiquette. As he is the Head of Queens' College, his vote may be somewhat more than that of a common man. I do not augur so well from your having Ld. Hardwicke & Co. your partizans, for there is always a strong jealousy of them. I could wish you & press your cause, as I have done it, upon your infinite superiority in the Science of Botany.

Having occupied the botany chair for sixty-five years Martyn died in 1825, and was succeeded by J. S. Henslow, the mineralogist.

Although not generally ranked among botanists, the great chemist W. H. Wollaston has the credit of having been the first, in 1807, to give a scientific explanation of 'Fairy Rings'. He noticed 'that some species of fungi are always to be found at the margin of the dark ring of grass, if examined at the proper season'. It is told of him that his remarkable acuteness of vision enabled him, when on horseback, to detect small plants in hedgerows that others could see only at close quarters.

John Stevens Henslow (1796–1861) professing Mineralogy as well as Botany, did for the Cambridge Garden what Daubeny had done for the Oxford Physic Garden. But he was of a more practical turn of mind, for he revived the excellent ancient custom of the elder Martyn of conducting herbarizing parties into the country, and he was the first to organize some kind of practical work in botany for students on scientific lines.

In 1827 a Quarterly Reviewer considered the study of Botany to have then 'just awakened out of a 30 years' slumber'. More students were required. So in 1829 a Grace was passed requiring candidates for the degree of M.B. to attend a course of lectures in Botany and be examined by the Professor. The result was that Professor Henslow's Botanical Class soon averaged seventy students, and some 30 accompanied him in his herbarizing excursions in the neighbourhood.

And—let it never be forgotten—had there been no Henslow at Cambridge, there might have been no Darwin.

The study of Cryptogamic Botany also was greatly advanced by MILES JOSEPH BERKELEY (1803–89) of Christ's. He dealt with our native Fungi for Smith's *English Flora* 1836, to be followed by his *Decades of Fungi* 1844–56. In the course of his review of the group, the cause of many plant diseases were the subjects of special attention, notably *Phytophthora infestans* which caused the deadly potato disease in Ireland in 1846, which, with other plant parasites he discussed in the early numbers of the *Gardener's Chronicle*. As Cryptogamic assistant at Kew he described the fungi collected by Darwin on the 'Beagle'. A large collection of Algae was left by him to Cambridge.

As our leading Cryptogamic taxonomist he was succeeded by HARRY MARSHALL WARD (1854–1906) of his own College of Christ's, a leading authority on bacteria and fungi. When quite a young man Ward went out to Ceylon, and there worked out the life history of the Uredine fungus, *Hemileia vastatrix*, which had by attacking the leaves of the coffee plant practically destroyed the trade in coffee of that island. A remedy was not to be found, so he recommended the planters to grow tea. For a time he was Botanical Professor at Cooper's Hill, returning to Cambridge as Professor in 1895. It was then that the present School of Botany was erected and was, 'and still is, second to none in Great Britain in size and completeness of equipment'. As one of the 'Makers of British Botany', his lifework was described by Sir William Thistleton-Dyer in 1913.

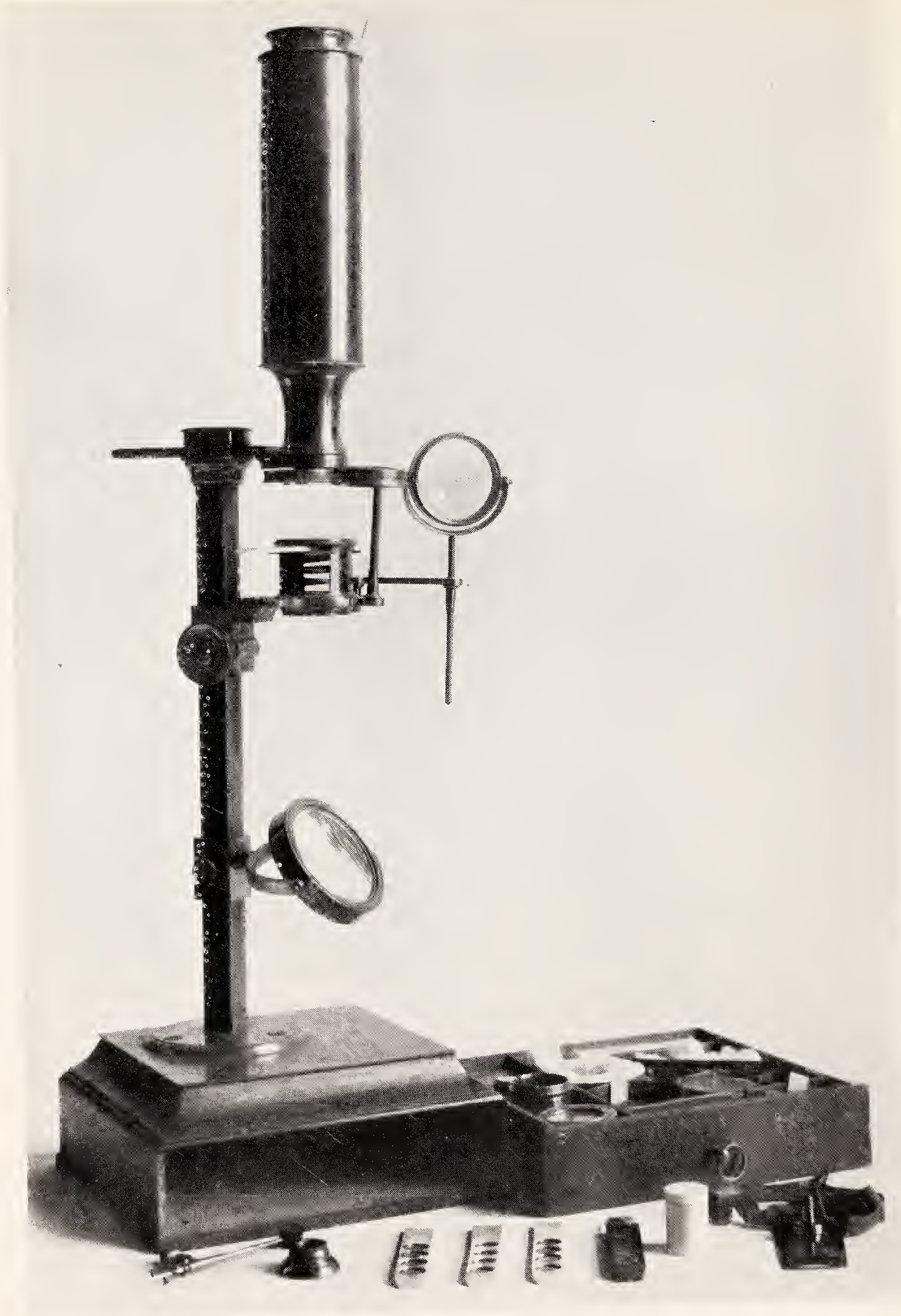
THE PROFESSORSHIP OF BOTANY, 1724

1.	RICHARD BRADLEY	1724
2.	JOHN MARTYN	1732
3.	THOMAS MARTYN	1762
4.	JOHN STEVENS HENSLOW	1825
5.	CHARLES CARDALE BABINGTON	1861
6.	HARRY MARSHALL WARD	1896
7.	ALBERT CHARLES SEWARD	1906
8.	FREDERICK TOM BROOKS	1936

G. Murray Bower Scott Clarke Lankester Goebel Balfour Traill Blyth
Weiss Marshall-Ward
Hartog Errera Carruthers Wager Dyer Seward Trimen Green

BOTANISTS AT THE BRITISH ASSOCIATION IN 1892

Edinburgh Meeting



ERASMUS DARWIN'S MICROSCOPE

By courtesy of the Derby Museum

MICROSCOPES IN THE BOTANICAL LABORATORY.

It is probable that several of the older microscopes listed below were used by, or in the time of, Professor Henslow and were given by his son. The early microscope No. 174 by James Smith is not only very interesting for its own sake, but has the added association value of having belonged to Charles Darwin, whose red pocket-handkerchief is still covering the instrument.

304. 'Aquatic' Microscope. c. 1764.

By 'DOLLOND LONDON'.

A type much used in the 18th century for the study of pond-life, &c. This set includes an instrument of the earlier screw-barrel form, also 4 ivory slides and mica coverslips. In box $9 \times 5\frac{1}{2}$ inches.

Erasmus Darwin's Large Microscope. 18th cent.

Derby Museum.

Type of Jones's Improved Microscope.

305. Miniature Model Microscope.

Signed: 'CARY LONDON'.

Pillar hinged to oval base by ball and socket joint. Stage focusing with rotating slide-carrier, condenser and stage forceps. Conical tube on adjustable arm with rack work. In box $6\frac{1}{2} \times 3\frac{1}{3} \times 2\frac{3}{4}$ inches.

3 minute O.G.'s. Dissecting lens. 3 opaque objects in circular card mounts. Wing of [Peacock] Butterfly, Wing of Moth, [Elytra of] Diamond Beetle. Glass slide $2\frac{1}{2} \times \frac{1}{2}$ in.

306. Large Microscope. c. 1840.

Inscribed '*A. Ross London* [No.] 1783'.

Height 20 inches. Stage carrying a sliding object-carrier, and a removable ring of 3 diaphragms. Eyepieces A, B, C, D, and Micrometer scale. With later fitting for sub-stage (missing). Parabolic dark ground illuminator.

O.G.'s: 1-inch *A. Ross London*; $\frac{1}{4}$-inch *A. Ross London*; $\frac{1}{7}$-inch *Ross London* with correction-collar for use with erecting-glass.

307. Dissecting Microscope. 1839.

By '*A. Ross London*'.

Mounted on a pillar supported by a flat 3-footed triangular base. Stage, clamped by 2 screws to pillar, is perforated for 2 circular glass plates and is slotted for a slider. O.G.'s: 1 in., $\frac{1}{2}$ in., $\frac{1}{4}$ in. Lens-holder moved by rack and pinion. Cf. Art. 'Microscope', *Penny Cyclopaedia*, 1839. J. R. M. S. 1900, p. 425.

308. Charles Darwin's Large Microscope. c. 1847.

Signed: 'Jas. Smith LONDON [No.] 143'.

Height 16 inches. Tube on trunnions mounted on two turned pillars. Limb of Lister form, carrying tube with rack coarse adjustment lever. Fine adjustment to O.G. tube. Straight double nose-piece with 1 in. and $\frac{1}{2}$ in. O.G.'s (?). No sub-stage.

Stage-fitting missing, but its Diaphragm, Focussing Fitting for holding condenser-carrier, 2 sliders, mirror preserved. Bulls-eye condenser.

Covered with red pocket-handkerchief 30 inches square marked C.D.[arwin]. With Darwin's MSS. notes on the use of the instrument.

Type described in *Micr. Journal* 1842.

309. Large Microscope. 1851.

Marked on tube: 'Smith & Beck 6 Coleman St. London 587'. Bought by Prof. J. S. Henslow.

Tube-length alterable by rack and pinion from 9 in. to 12 in. No fine adjustment.

Limb of Lister form. Large stage with sliding carrier. 2 E.P.'s. $\frac{2}{3}$-in. O.G., with correction for erecting-glass.

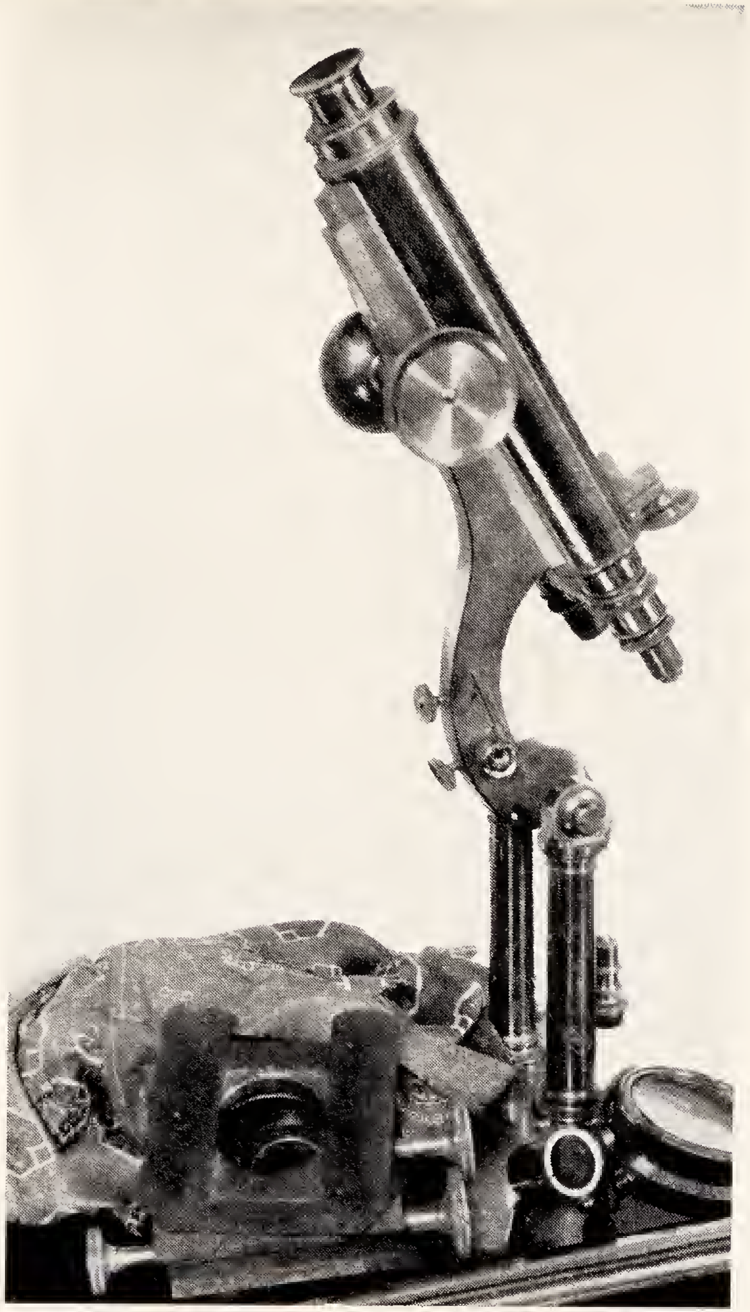
310. The International Microscope. 1870.

Signed: 'W. Pillischer London Manufacturer No. 3428'.

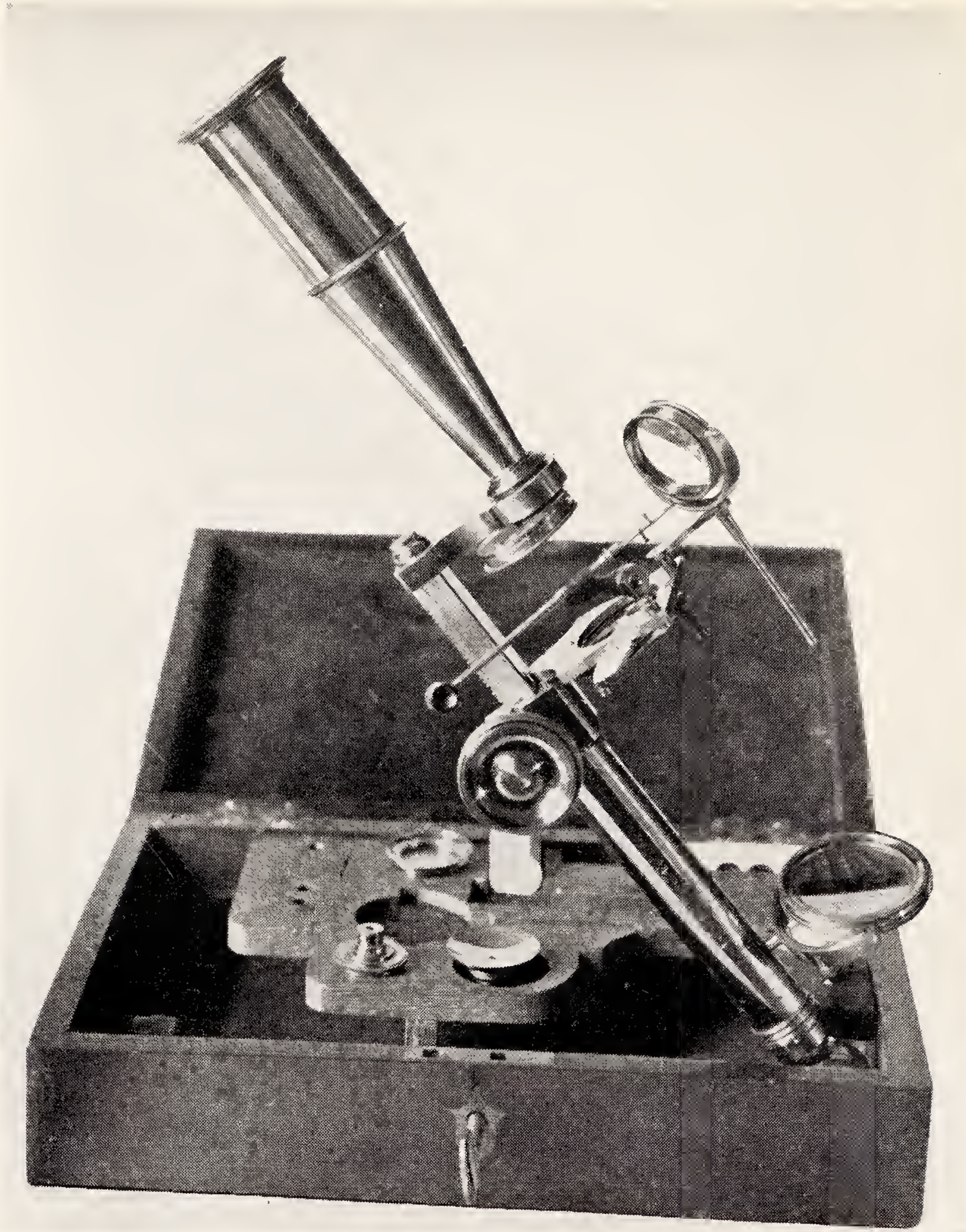
Short body. Screw fine adjustment at top of pillar. Powell's mechanical stage, with concentric screw.

$\frac{7}{8}$-in. diam. E.P.'s 'A and C.', O.G. $\frac{1}{7}$ in. Polarizing Apparatus. Nosepiece by Zeiss Jena.

The first model with the fine adjustment to be carried on the pillar, and with other features of interest which were subsequently copied by German makers.



NO. 308. DARWIN'S MICROSCOPE BY JAS. SMITH



DOLLOND MICROSCOPE
(Resembling No. 621 in the Crisp Collection)

311. Sorby's Microspectroscope for Ross Microscope. **c. 1878.**

By '*John Browning* LONDON'.

Marked 'From Prof. G. Henslow'.

In box with drawing-prism and slide.

Cf. *Trans. R. Micr. Soc.*, i. 1878.

To facilitate spectroscopic examination of very small quantities of coloured substances, and to determine the position of their absorption bands relatively to the known Fraunhofer lines.

312. F. H. Wenham's Large Radial Microscope.

c. 1882–6.

Signed and numbered: 'ROSS 5300 LONDON'.

For oblique illumination in altitude and azimuth.

Mechanical stage is a modification of Tulley's, by which rectilinear motions are actuated by milled heads placed within the circumference of the stage. Cf. Mayall, *Cantor Lecture* 1886.

Francis Darwin's Small Microscope.

Given in his memory to his godson, Francis T. N. Elborn of the Botany School.

School of Biochemistry

313. Micromanipulator. **c. 1914.**

Devised by M. B. R. Swann.

314. Micromanipulator. **c. 1922.**

School of Biochemistry.

Devised by H. Hartridge.

The micromanipulator, though it can be traced back to a rough apparatus made by Schmidt during the American civil war, did not become a really practical tool until about 1924 in the hands of Robert Chambers, who has since brought it to a great degree of perfection. It is widely used for all kinds of microsurgical operations on cells, for micro-injections and for the isolation of single bacteria. (Dr. Needham.)

XV

HUSBANDRY AND HORTICULTURE

The soil of the neighbourhood of Ely seems to have been recognized from a very early period as favourable for the growth of fruit. Three acres of vineyard at Ely are mentioned in Domesday, and the forgotten chronicler of 1368 speaks of this vineyard as being still very productive, 'multum dans vinea vinum'. About 1800 the cherry gardens were extensive and great quantities of asparagus and various other vegetables were sent by market gardeners to Cambridge and London.

The history of the College Gardens along the Cam well deserves to be told in full. The land on the west bank was originally an unenclosed common belonging to the town, frequently referred to as the West Field.

One of the older enclosures was the walled kitchen-garden of Queens' College, laid out on a plot purchased in 1475 for 40 marks.

In 1447 King's College received from Henry VI Butt Close, a plot of land lying between the ditch on the south side of the College and Garret Hostel Lane. St. John's inherited a meadow from the Hospital, but in 1610–11 added to it their Wilderness by purchase partly from the town, partly from Corpus Christi College, and about the same time Trinity acquired their 'quarters' from the town by exchange for 'Parker's piece'.

In 1637 Clare Hall acquired their Fellows' Garden and Avenue from King's College.

In 1608–9 300 mulberry plants were purchased by Christ's College, presumably for the Fellows' Garden, immediately on receipt of the Proclamation issued by James I

to spread the growing of this tree for feeding silkworms. One of these is believed to have survived as 'Milton's Mulberry'.

The trees planted during the first half of the seventeenth century include elm and sycamore by the Bowling Green. '86 trees and 600 setts' at St. John's 1629–30. Also 72 ash and 28 elms in Queens' College grove in 1630–4.

'10 young elmes to set in ye High walks' were purchased in 1684 from King's College, which suggests that this college was engaged in extensive planting at that time.

In 1674 the avenue of limes between Trinity bridge and the 'field-gate' was planted, and the part between the College and the bridge was added in 1717.

Queens' College planted limes in 1732.

Possible evidence for the survival of classical tradition in the eastern counties is afforded by the occurrence in Colchester Castle of a unique manuscript translation of Palladius's *On Husbondrie,* of about 1420 A.D. Therein the tending of the Vineyard and of Fruit trees is very fully described in verse, and it must have been from some such exemplar as this that Master FITZHERBERT, of Oxford and Derbyshire, would have taken the idea of producing *A newe tracte or treatyse most profytable for all Husbandemen, and very frutefull for all other persons to rede,* of which the better-known edition of 1534 was simply entitled *The Boke of Husbandry.*

One or other of these works must surely have been known to THOMAS TUSSER who had come up to King's College (1543) from Wallingford and Eton. His *A hundredth good pointes of husbandrie,* London 1557, and his *Five hundreth points of good husbandry united* 1573–7, have remained in popular favour for centuries. In real life Tusser was a prisoner for debt, but now his works are among the treasures of the sale-room, much sought after as classics of abiding interest. He died in 1580.

Next we have the rare work of BARNABE GOOGE (c 1540–94), who migrated from Christ's to New College.

When resident at Kingston he published *Foure Bookes of Husbandrie collected by Conradus Heresbachius . . . containing the whole art and trade of Husbandrie, Gardening, Graffing, and planting, with the antiquitie and commendation*

thereof. Newly Englished, and increased by Barnabe Googe, Esq. London. 1577.

A third author, well known for his medical books, was William Bullen *b.* in Isle of Ely c. 1554, who practised as a Physician at Durham, and died 7 Jan. 1575–6. He promoted the art of gardening and the general cultivation of the land. Cf. Pulteney's *Botanical Sketches.*

The works of such writers as these show the interest that was being taken in making the land yield crops according to its capabilities. And so we find that on suitable lowlands in Cambridge, the planting of willows was being encouraged. According to the Corporation Day-book it was lawful in 1570

for every alderman of this town, to plant and set six score poles with willows, and every other burgess of this town inhabiting within the same, to plant and set four score poles; and the same willows be placed and set in such place and places, and in such order, form, and fashion, upon the commons, drains, moors, marshes and fens belonging to the town of Cambridge, as the Mayor of the same town for the time being, or his deputy for that purposes, shall name and appoint.

Also, that it shall be lawful for every burgess of this town, to lop and top all such willows as he shall so set, and the profits thereof coming, to employ at his pleasure.

Also, that every free burgess shall scour and cleanse the one half of such common drains and ditches as his willows shall so be planted on, at his own proper costs and charges. And if he do plant on both sides, then to scour the ditch on both sides, as far as his willows do reach. . . .

And if any person or persons shall at any time or times hereafter cut down, saw or hew, pluck up by the root, bark, spoil or destroy, any willow or willows now set or hereafter to be set, in any part of the bounds or commons of this town, that then every such offender shall suffer such pains, forfeitures and losses, as the common laws of this realm shall appoint or assign.

Fuller, too, appreciated the 'Willow—a sad tree which delighteth in moist places', especially in the Isle of Ely 'where its roots strengthen their banks, and lop affords fuell for their fire. It groweth incredibly fast: it being

a by-word in the country that the profit by Willows will buy the owner a House, before that by other trees will pay for his Saddle.'

Hugh Platt was a scholar of wide interests. He matriculated at St. John's in November 1568, and became an indefatigable student of chemistry, alchemy, astronomy, mineralogy, horticulture, agriculture, physic, and mechanics. In 1594 he was living at Bishop's hall in Bethnall Green. He was knighted in 1605, and died the same year. His son William became a benefactor to St. John's college. His published works include the following:

1. *The Floures of Philosophie*, 1572—includes 'The description of my Garden, with the sundrie sorts of Floures that grow most freshely in the same'. (One copy only known.)
2. *A Discoverie of certain English Wantes which are royally supplied in this Treatise.* 1575, 1596. Repr. Harleian Misc. vol. 9.
4. *A brief apologie of certen new invencions completed by H. Plat.* publ. 1593.
5. *The Jewell House of Art and Nature.* Conteining diuers rare and profitable Inuentions, together with sundry new experiments in the Art of Husbandry, Distillation and Moulding 1594, 1613. It consists of
   - i. Divers new experiments
   - ii. Divers conceits of Husbandry
   - iii. Chemical conclusions concerning Distillation.
   - iv. Of moulding, casting etc.
   - v. An offer of certain new inventions, which the author proposes to disclose upon reasonable considerations etc. An enlarged edition of 1653 has a discourse on minerals, stones, gums and rosins.
6. *Diverse new Sorts of Soyle not yet brought into any publique Use.* Lond. 1594.
7. *Discovery of certain English Wants; with their Supplies.* Lond. 1595.
8. *Sundrie new and Artificiall remedies against Famine, upon the occasion of the present Dearth.* 1596.
9. *The new found Arte of setting of Corne.* n.d. 8 chaps.
10. *Of Coal-Balls for Fewell, wherein Sea coal is, by the mixture*

of other combustible bodies, both sweetened and multiplied. Lond. 1603.

11. *Floras Paradise.* 1608.
12. *Delightes for Ladies to adorne their persons.* 1602, 9, 11, 17, 40.
13. *A Closet for Ladies . . . Preserving*
14. *The Garden of Eden.*

He also left a number of manuscripts, which appear to be unpublished:

MSS. Addit. 2171 De terra Lemnia. 2172, 2215 Letter on Alchemy. 2194, 2195, 2223 Collections relating to Alchemy. 2197 Secrets of physick and surgery. 2203 art. 2 Receipts for perfumes. 2203 art. 7 Experimenta rerumque metamorphoesis. 2209, 3690 Medical receipts, practice etc. 2210 Secreta Secretorum. 2245 Secrets of metalls, minerals, animals. 2246 Collections of alchemical treatises. 3690 art. 2 Dispositions of the seven planets. 3690 art. 3 Influence of the planets, signs etc.

In 1605 Francis Bacon perceived the importance of the Physic Garden. 'We see likewise that some places instituted for physic have annexed the commodity of gardens for simples of all sorts, and do likewise command the use of dead bodies for anatomies.'[1] And indeed, Cambridge has never been without the amenity of gardens. Those College gardens which were in existence in 1610 are shown in plan on Speed's map for that year. 'Kinges colledge backesides,' Peterhouse Groves, Wilderness of St. John's, Walks of Trinity, Christ's, Emmanuel, and Sidney Gardens, Queens' and Trinity Hall Groves are all marked.

In 1676 we find Newton asking Oldenburg: What are the best cider apples and what degree of ripeness ought they to have? 'Whether it be material to press them as soon as gathered, or to pare them? Whether there be any circumstances to be observed in pressing them? or what is the best way to do it?'

Newton had a small garden between the College and the road on the right-hand side on entering the great Gate of Trinity. 'He was very curious in his garden, which was never out at order, in which he would at some seldome time take a short walk or two, not enduring to see a weed in it.' 1683–9.

[1] *Advancement of Learning*, ii.

About 1674 to 1681 a most interesting horticultural experiment was being made by THOMAS SCLATER, M.D., later a benefactor to Trinity College, and a man of parts. His character was summed up by Dr. Ralph Cudworth, master of Christ's, in a letter dated 1 January 1658 to Secretary Thurloe, advocating the selection of Sclater as a burgess of the University:

> This gentleman is well known by many of us to be a very ingenious person of very good abilities, and one that we doubt not will readily concurre with such resolutions, as tend to the settlement and establishment of the commonwealth, as well as mind the interest of the University.[1]

In 1659 he was one of the delegates chosen to exhibit to the Lord Protector a petition against the erection of a new University at Durham. And on 27 September 1681, when Charles II visited Cambridge, he as High Sheriff of the County, with his men in their liveries, met both their Majesties about two miles from Cambridge.

In 1675 late in life he purchased the estate of Linton and Catley House and proceeded to study farming, and especially horticulture in all its details. The plans of his plantings are recorded in notebooks from which I have been permitted to extract, through the courtesy of their owner, Mrs. Ruck-Keene, whose husband's ancestors acquired the Sclater estates of Linton and Catley in 1771. Sclater's notes are printed as an Appendix, p. 446.

Sclater would certainly have been one to recognize the necessity of a physic garden for Cambridge, and in 1695 a proposal was actually made to establish a garden such as Oxford had had since 1621. The promoters even got as far as measuring the ground and drawing a plan in 1696, but the scheme did not mature. About 1724 hopes were again raised, when RICHARD BRADLEY, F.R.S., was generally believed to be going to provide the University with a public Botanical Garden by his own private purse and personal interest. In this he was encouraged by the conferment on him of the title of Professor of Botany by a grace on 10 November 1724. But nothing was done,

[1] *Thurloe's State Papers*, vii. 559–587.

beyond his publicly repeating his promise in lectures in 1729; and he seems to have become more and more irregular in his teaching duties; but he held on till 1732.

Prof. Bradley advocated the use of the Thermometer for hot-houses. He pointed out that the first gardener to succeed in growing ripe, well-flavoured Pine-apples was Mr. Le Cour of Leyden, and it was from him that the English stock originated.

Not long before 1726, Bradley saw about 40 plants fruiting at Sir Matthew Decker's at Richmond, grown by his judicious gardener Mr. Henry Telende over a hot-bed of Tanner's bark, the temperature of which is judged of by a Thermometer.

'It has a tube about 24 inches long and a diameter of 1/8th inch.

When the Spirit rises to	15	inches, the air is	*cold* for his plants
,,	$16\frac{1}{2}$	,,	*temperate*
,,	18	,,	*warm* (Pine-apple heat
,,	20	,,	*hot*
,,	$21\frac{1}{2}$	,,	*sultry*

I think there cannot be any instrument more useful to Gardiners. In these thermometers I shall mark the names of the principal places, with their degrees of latitude and Summer Heat, whether they lie N. or S. of the Line.

The instrument may be had of Mr. John Fowler, Mathematical Instrument Maker, in Swithin's Alley near the Royal Exchange.

I have seen above 40 degrees difference in some thermometers with printed scales.

Patrick's Thermometer has a scale of ninety degrees numbered from the top downwards, with a moveable Index joining to it.'

Bradley was the author of *New Improvements of Planting and Gardening both philosophical and practical. . . . With a new invention whereby more Designs of Garden Plats may be made in an Hour, than can be found in all the Books of Gardening yet extant.* 6th ed. 1731.

College Gardens in 1753

In the following contemporary descriptions the College Gardens were described as 'Curiosities'.

But the chief beauty of this Lodge [of PEMBROKE] is (in my opinion) the Gardens, and therein the Water Works, contrived by the present Master [Professor Roger Long, F.R.S.] (and here let me tell you, he is a very great Mechanic), which supplies a beautiful and large Bason in the middle of the Garden, and wherein he often diverts himself in a Machine of his own contrivance, to go with the Foot as he rides therein.

The Fellows Garden is a large spot of ground, wherein is a good Bowling-Green, but what it is chiefly noted for, is a long and fine Gravel-walk, at the foot of a South wall, which is counted one of the warmest winter walks in the University.

There are besides several other Gardens, belonging to the Apartments of particular Fellows, in one of which is another small and simple yet well-contrived Water-work, which is continually supplying a large Cold-bath with fresh Water; the overplus of which runs through the second Court, and so into the King's Ditch.

At CORPUS CHRISTI COLLEGE the Lodge has 'a pretty Flower Garden'. The Fellows Gardens are very pleasant, having a grand Bowling-green, a beautiful Summer house with variety of wall and other fruit, all which are kept in excellent order.

CAIUS COLLEGE being surrounded with Lanes on three sides and the street on the East, cannot be thought to contain much Garden Ground, yet besides the Garden belonging to the Master, the Fellows have a small one, or rather Orchard; and the Court next the street is handsomely planted with Lime-trees.

QUEENS' COLLEGE Gardens are situated on both sides of the Cam, having a Bridge of communication between them, they are very extensive & neatly kept; having fine Walks, both of grass and gravel, with a very good Bowling Green, all which with the pleasant gliding of the River, on whose banks they are situated, make it a most agreeable place.

The Flower Garden at ST. CATHARINE'S is a small but pretty spot, and kept very neat, and on a pedestal in the centre stood

a statue of Charity with a child at her breast, and two more by her side; but was a few years ago taken away, tho' I think it was an ornament to the Garden; but I submit to the superior judgment of that learned Society, who doubtless thought otherwise.

The Fellows Garden at JESUS COLLEGE, has pleasant and extensive walks, meadows & groves, and the rural situation on the bank of the Cam, makes it an agreeable place, being out of the noise and hurry of the town, and so the more proper for a place of study.

The Gardens at CHRIST'S are large, private and kept in excellent order; having a neat *Bowling Green*, and a very good *Cold-Bath* etc.

But should I speak particularly of the Courts, Bridge of ST. JOHN'S COLLEGE, its long and spacious Shady-Walks, Groves, Canals, Bowling Green, etc I should much exceed my intended brevity; tho' I cannot help taking notice of a monstrous large Elm in these walks, which is much admired by all Strangers.

MAGDALENE COLLEGE. The Gardens and Terras-Walks which command a view of the River Cam, and adjacent country are very agreeable and wholly rural.

The Gardens and Bowling Green of TRINITY are kept in excellent Order, especially the Vice-Master's Garden (who is a very great Virtuoso in Flowers etc) where are abundance of Exortic plants, flowers & fruits, brought from both the Indies, and where is annually raised a great number of Ananas or Pine-Apples in the greatest perfection.

The Fellows Gardens etc at EMMANUEL are very agreeable, and kept in excellent order, which together with the Bath, Bowling Green, Summer house etc make it a little Paradice.

The Fellows Garden at SIDNEY SUSSEX is a most delightful place, having a noble Bowling Green, a fine Alcove, and spacious Gravel-Walks.

Some forty years later a small triangular patch on the

RICARDUS. WALKER. S.T.P.

HORT. BOTAN. CANTABR.

FUNDATOR.

south side of the front of Trinity Hall was planted by the tutor and became celebrated in both universities.

> ‘A little garden little Jowett made,
> And fenced it with a little palisade;
> If you would know the mind of little Jowett,
> This little garden don't a little show it.’

The Botanic Garden

In 1762 Dr. Richard Walker, Vice-master of Trinity College 1734–64, and a loyal supporter of Bentley in his quarrels with the fellows, by indentures of lease and release dated respectively the 24th and 25th August (after setting forth the advantages resulting from the study of Botany), stated that nothing could be more conducive to the revival of that study than having a public Botanic Garden. So he had, he declared, purchased certain messuages, lands, tenements, and hereditaments, and had appropriated a part of the lands for such a garden, into which many plants had already been introduced, and a greenhouse had been begun to be erected therein, and he had appropriated a freehold messuage adjoining thereto. And for or towards the support and maintenance of the garden, he designed the other properties.

All for a Botanic Garden for the use and benefit of the University. Perpetual Governors and Visitors were to be the Chancellor, or in his absence the Vice-Chancellor, Master of Trinity College, Provost of King's College, Master of St. John's College and the Professor of Physic. The Officers were to be a Reader on Botany and a Curator or Superintendent, the former to be proficient in botany and capable to read lectures in Latin or English. As we have seen Thomas Martyn was appointed first Reader, and Charles, son of Philip Miller of Chelsea, as first Curator of the garden. A public subscription list was opened with the result that between 1762 and 1783 a total sum of £3,333 9*s*. was received.

So engrossed were Dr. Walker's thoughts with his gardening that a pleasant story was often repeated of him. When he was told of a brother florist's death by suicide

in the spring, he is said to have exclaimed, 'Is it possible? Now at the beginning of tulip time.'

And so the idea of a Botanic Garden mooted in 1696, and revived in 1724 and in 1731, materialized in 1762.

In 1768 WALTER TITLEY, fellow of Trinity 1725 and Envoy to the Court of Denmark 1730–68, bequeathed £500 to Cambridge to be disposed as the Vice-Chancellor might direct. It was appropriated to a fund for an Amphitheatre for public lectures and musical performances, but the project failed, and this notwithstanding he was pressed to give it to the Botanic Garden.

The occasion of a visit from the King of Denmark on 29 August 1768 led to at least two amusing incidents. The Vice-Chancellor, considering the Garden-produce inadequate to so great an occasion, wrote to Lord Montfort's gardener, 'Three or four ripe Pine-apples, & some Melons are wanted, which the Vice-Chancellor desires Lord Montford's gardener to send him packed up *with great care* by the bearer.' Lord Montfort not unnaturally considered the Vice-Chancellor's carriage to be 'rather forward and absurd', and said so.

In 1779 the trees on Erasmus's walk at the north end of Queens' Green were ordered to be sold, but the University paid £50 to preserve them.

The Senate appointed a Syndicate to erect a building for the lectures of the Botanical and Jacksonian Professors, on the ground belonging to the Trustees of the Botanic Garden, at an expense not exceeding £1,500. *Stat. Acad. Camb.*, 26 May 1784, p. 449.

Agriculture

The following advertisement tells its own tale:

We poor farmers who hire lands in the parish of Grantchester and fields of Coton, having some of our corn still standing, and some lying on the ground, do most humbly beg the favour of the Cambridge Gunners, Coursers and Poachers (whether Gentlemen, Barbers or Gips of Colleges) to let us get home our crops, even after the First of September, without riding or hunting their dogs over *our* property . . . etc.

Cambridge Chronicle, 1 Sept. 1787.

In 1786 by the removal of a number of locks, which were formerly considered essential to the navigation of the Cam, and by deepening the channel, they have at the same time improved the river, and drained the lands to a considerable distance from its banks. At a few feet below the surface they meet with clay, which proves the most valuable manure to the land; the crops are most abundant, and in a few years the rents will be much higher than those of the best uplands. A large steam-engine, which was erected for the purpose of throwing the superfluous water into the river, is frequently employed in throwing it back again to supply the cattle with water, of which in dry summers they are frequently in want.

A general survey of the state of Agriculture of the county of Cambridge was begun at the request of the Board of Agriculture by Charles Vancouver in October 1793. The immediate occasion for the enquiry seems to have been a proposal in contemplation to be brought before Parliament, of diverting the course of the river Ouse from its channel between Eau-brink and the Haven of Lynn. Vancouver walked over the whole of the fenny country, and by daily conversations with the residents acquired a valuable store of information as to the structure of the country; the nature of the soils; the usual mode of cultivation; the produce per statute acre, taken on an average of five years; and many other apposite data. In an Appendix, dated from the Hoop-Inn, Cambridge, 1 Feb. 1794, he discusses the effect of the Eau-brink cut, and concludes that though it will benefit the adjoining fens, it will not relieve the middle and fourth levels of the fens.

The report was illustrated with an agricultural map coloured to show the soils of the county, and was sent out with a *Sketch of a Proposal to make an actual Survey and publish an Accurate Map of the County of Cambridgeshire.* By Charles Vancouver.

The size of the map to be one Inch to the mile. The Price to subscribers One Guinea and a Half.

The Map will exhibit the general surface of the Country, with all its irregularities etc. . . . the Quantity of Inclosed land . . . will be distinguished in every Parish from the open

Fields and Commons. The Woods, Fens & low Grounds will be particularly marked and accurately ascertained. The respective Distance of each Parish Church from the Vniversity of *Cambridge*, will be correctly noticed. . . .

Names of subscribers will be received by Mr. John Carey, Map Engraver No. 181 Strand; Mr. Marshall of Lynn and Mr. Lunn of Cambridge.

On Nov. 6, 1795 a violent hurricane blew down many of the trees in the College walks, especially Milton's mulberry tree at Christ's College, and a poplar at St. John's which was 42 feet in length and 29½ inches in girth, and which with its three arms contained 328 cubic feet. *Cambridge Chronicle*, 14 Nov. 1795.

On 2 April 1797 the Prince and Princess of Orange visited the Physick Garden etc.

Dr. WILLIAM MAKEPEACE THACKERAY of St. John's and Trinity, having taken medical degrees at Edinburgh and started in practice at Denbigh and Chester, devoted himself to the afforestation of unenclosed land in Flintshire. He attributed his success to his peculiar method of pruning the young trees. Near the end of October he taught his foresters to select a leading shoot in each tree, when about 2 or 3 ft. high; he then cut off with a sharp knife, and as close to the tree as possible, four or five of the shoots immediately below those he had pruned the year before—then beginning at the top, and, contrary to the usual practice, working downwards. (Gunning *c.* 1805.) Whether he learnt this practice at Cambridge, we do not know.

The Cambridgeshire Horticultural Society was established at a Meeting held at the Red Lion on 10 March 1824. The Earl of Hardwicke K.G. was in the chair. Ten years later the Statistical Society was founded in the rooms of the Horticultural Society.

In 1841 improvements of the Commons were strongly urged by a committee, who were of opinion that there was one portion which

> ought never, upon any pretence, either to be built upon or let for any private purpose—namely, Parker's Piece, containing about 20 acres, which should, in their judgment, for ever remain, as it is devoted to public purposes. So far, indeed, from

wishing that this splendid space should be encroached upon, they recommend that an addition be made to it, by purchasing from those who have rights there all that portion of the Common set out by the Commissioners under the Barnwell Inclosure Act, which lies between the present south-eastern boundary of Parker's Piece and the public roads which run along its sides, being rather more than 4 acres. If this were done, and the ground levelled, and along its skirts planted, it would form one of the noblest areas for public use of any in the kingdom. Nor would your Committee stop here: they would further recommend that an ample reserve of land be made for public walks, particularly along the south-western bank of the river. There are certain parts of Midsummer Common which have not yet been spoken of. There are above 25 acres to the north, and 28 acres to the east, of the projected new road to Chesterton, which would be of a value they hardly know how to compute, if let to market gardeners, or others interested in the pursuit of horticulture.

The Royal Agricultural Society met in Cambridge on 14–15 July 1840 and Professor Buckland of Oxford spoke at a dinner at Downing where there was a grand horticultural fête. A good idea of the gathering is given by William Lucas of Hitchin (1804–61) who started from home at 5 o'clock to attend the fete which was attended by some 60,000 people.

Our horses and gigs were most cheerfully taken in at the yard of Commings & Co. of whom we sometimes buy corn. The show of stock and implements was admirably arranged in Parker's Piece where the elections take place. The Durham bulls and heifers seemed properly to occupy the first class and were surprising animals, but the most attractive object was a Hereford bull of the Duke of Bedford's. I was not much struck by the horses, but the sheep, especially the South Down rams were greatly admired; in the implements Ransoms cut a very great show, they had more than 80 different kinds of plough and appeared to be taking orders rapidly, many hands being employed by them. The pigs as usual were trembling masses of fat. Two of the boars had been fighting and one was gored frightfully in the side, but no tusks could reach his vitals. . . . It was industriously announced that Acland, one of the Anti-

Corn Law lecturers, was to hold forth in the evening; he is a most impudent little teaser to the landed monopolists. . . .

The Pavilion was erected in the quadrangle of Downing College and was elegantly constructed. . . . A flower-show was spiritedly got up by Widnal for the benefit of Addenbrook's Hospital in the great pavilion, but for which sort of thing Cambridge is not a good neighbourhood.

In 1847 on July 6 the grounds of Downing College were used for a most successful Horticultural Fête.

The old Botanic Garden was superseded by the present one in 1851, and the 'Museums' were built upon its site. The sum of £237 3*s*. 4*d*. was voted for its support.

Commission reported that new arrangements will be necessary in future appointments to the Professorship of Botany, and that it would be expedient to give to the Professor the general superintendence of the Botanic Garden. 30 Aug. 1852.

Among the various efforts that have been directed towards the protection and preservation of the natural beauty and antiquity of the country-side none have been more praiseworthy and altruistic than those which have resulted in the preservation of Wicken Fen as a never to be touched Nature Reserve for the flora and fauna that was characteristic of the whole of the 'Great Level' prior to its drainage in the seventeenth century. Professor E. J. Salisbury has recently written the following appreciation:

'Interesting to the botanist as the home of *Liparis loeselii*, *Viola stagnina*, *Cladium mariscus*, *Lathyrus palustris* and a number of other rare or local species, Wicken Fen has equal attractions for the zoologist as a locality for the very rare water beetle *Hydrochus carinatus*, the swallow-tail butterfly and many other interesting animals. Unfortunately the changes, initiated by the artificial drainage of the past, still continue and no less than six of the Lepidoptera formerly characteristic of Wicken, including the large copper (*Ocneria dispar*) and a moth, *Laelia coenosa*, are no longer to be found there. So too with the flora, *Senecio paludosus* and *Typha minima* would both appear to have become extinct. Such changes in the past suggest an especial suitability in this area as the subject of intensive study, particularly with regard to the fluctua-

THE OLD BOTANIC GARDEN

tions in frequency, which plants and animals alike exhibit, and respecting the underlying causal factors of which we are so ignorant. These fluctuations are well illustrated at Wicken by the moth *Hydriomena sagittata* which has twice, within recent years, been apparently so scarce that it was feared to be on the verge of extinction.

'The late Prof. Yapp laid a valuable foundation for future work in his account of the structure of fen vegetation from the static point of view, whilst Godwin and Tansley here develop the dynamic aspect as presented in the fen successions of which, in addition to the familiar primary succession passing from reed-swamp through 'carr' to deciduous woodland, there are recognized several 'deflected' successions consequent upon the interference of man. Data respecting the changes in level of the soil water show that the water table is slightly convex in winter and in summer concave owing to the high rate of transpiration, whilst the normally alkaline soil water contains only a small amount of dissolved oxygen and a high content of carbon dioxide.'

From a Review of *The Natural History of Wicken Fen* in *Nature* 1933.

XVI

GEOLOGY

Martin Lister of St. John's, born at Radcliff in 1638, had a great reputation as a medical man, a capacity in which he accompanied Lord Portland to Paris in 1698, and became physician to Queen Anne in 1709. He died in 1711.

At the age of 30 Lister collected living shells, and became the foremost authority on that group. His studies led him to examine fossil shells and to compare them with living species. He soon observed that different rocks contain characteristic fossils, and that these often had their counterparts among the living. He, or rather his sisters, made careful drawings of shells, both living and fossil. But he never for a moment believed that fossil shells had ever lived, or had been produced by animals that were once alive. *Philosophical Transactions* 1671.

It is difficult to explain a mentality which on the one hand takes the greatest pains to demonstrate the minutest resemblances, yet emphasizes the proposition that fossil shells are merely rude imitations of the real forms, imitations produced in rock by unknown causes, one of which was a *vis plastica*. In this belief Lister was supported by Lhwyd of Oxford and Lang of Lucerne, but all were leaders of a forlorn hope. And the error of their ideas was soon to be exposed by the work of Nikolaus Steno, Robert Hooke, and, in Cambridge by John Ray and John Woodward.

Once the organic origin and historical significance of fossil remains had been generally accepted, then the Church, which had previously been strangely uninformed about fossils, took advantage of the latest scientific theory and

claimed all fossils as the remains of life before the Flood, which had been overwhelmed and buried in the earth by that great catastrophe. All considered that Geology was worthy of study as an illustration of the Mosaic record.

Religious geologists accordingly made their accounts of the evolution of the surface of the earth conform with the Mosaic account of the Creation. Leibnitz (1646–1716) was particularly conscientious in this matter, and he was followed by the more thoughtful of the English geologists. The same trend of thought is conspicuous in the *Sacred Theory of the Earth* by Dr. THOMAS BURNET in 1681, in the *Natural History of the Earth and Terrestrial Bodies* by J. Woodward 1695, and in the *Three Physico-theological Discourses* of John Ray, 1693.

Dr. JOHN WOODWARD'S *Essay towards a Natural History of the Earth and Terrestrial Bodies, especially Minerals; as also of the Sea, Rivers, and Springs, with an account of the Universal Deluge* was an original work in which he described his large collections of fossils, minerals, metals, and rock specimens, with the view of accentuating his view that fossils represented bygone faunas and floras. Their present position in the earth he explained by a universal Deluge, the Great Flood of Noah.

From the great number of facts collected by him we might have expected his theoretical views to be sounder and less narrow than those of his contemporaries; but in his anxiety to accommodate all observed phenomena to the scriptural account of the Creation and the Deluge, he arrived at curiously erroneous results. He conceived 'the whole terrestrial globe to have been taken to pieces and dissolved at the flood, and the strata to have settled down from this promiscuous mass as any earthy sediment from a fluid.'[1] In corroboration of this view he insisted upon the fact that 'marine bodies are lodged in the strata according to the order of their gravity, the heavier shells in stone, the lighter in chalk, and so of the rest'. Ray immediately exposed the unfounded nature of this assertion, truly remarking that fossil bodies 'are often mingled, heavy with light, in the same stratum'; and he even went so far as to accuse Woodward of having 'invented the phenomena for

[1] *Essay towards a Natural History of the Earth*, 1695. Preface.

the sake of confirming his bold and strange hypothesis'. This, as Sir Charles Lyell, from whose *Principles* we are quoting these passages, observed, was—a strong expression from the pen of a contemporary. In letters to his scientific friends Ray was even more scathing. 'I take Dr. Woodward's account of the Gravity of these bodies to be a mere amusement, and a confus'd notion of no real use, & scarce intelligible to himself or others . . . our observations contradict him.'[1]

JOHN RAY of Trinity has the great credit of having been one of the first naturalists to perceive the great power of running water to produce changes on land; and in the encroachment of the sea upon the shores, he saw a not less potent geological factor. These two agencies, when continued for centuries, he deemed sufficient to produce results in a more natural manner than would be produced by crises or sudden cataclysms. Indeed he expressed surprise that the earth should not have proceeded more rapidly towards a general submersion beneath the sea.

Ray, however, had been a churchman before he became a geologist, and his divinity was inextricably intermingled with his science. So in his *Physico-theological Discourses* he is always intercalating quotations from the Christian fathers and prophets. He successively discusses former changes of the globe by the strict rules of induction, and speculates whether the sun, moon, and stars will share in the annihilation of our Earth at the era of the grand conflagration. The *Discourses*, three in number, were on, I. The Primitive CHAOS, and Creation of the World, II. The General DELUGE, its Causes and Effects, and III. The Dissolution of the WORLD and future Conflagration. 'Wherein are largely discussed The Production and Use of Mountains, the original of Fountains, of Formed Stones, and Sea-Fishes, Bones, and Shells found in the Earth; the Effects of particular Floods, and Inundations of the Sea; the Eruptions of Vulcano's; the Nature and Causes of Earthquakes.'

Subterranean phenomena were much discussed at this period. Ray's friend, Dr. TANCRED ROBINSON of St. John's

[1] Letter No. 175 of Ray to Lhwyd in 1697. Gunther, *Further Correspondence of John Ray*, 1928.

communicated his 'Observations on boiling Fountains and Subterranean Streams' to the Royal Society in 1685.

Ray's essay on Chaos proposes a system, which was, at any rate in part, borrowed from that of Robert Hooke, whose assistance he elsewhere handsomely acknowledged, 'whom for his learning and deep insight into the Mysteries of Nature, I deservedly honour'.

In the second essay on the Deluge he tells the reader that

'I think the most probable of all the causes I have heard assigned of the Deluge, which is, the Center of the Earth being at that time changed, and set nearer to the Centre or Middle of our Continent, whereupon the Atlantick and Pacifick Oceans must needs press upon the subterraneous abyss, and so by Mediation thereof, force the water upward, and at last compell it to run out at those wide mouths and apertures made by the Divine Power breaking up the fountains of the great Deep.'

The plan of the last essay was outlined by him in a letter, No. 109, to Edward Lhwyd at Oxford, dated 25 November 1691:

The Discourse concerning ye Dissolution of the World is finished & under ye Presse, so that I hope shortly to present you with the thing it self, wch might supersede any account of ye contents of it; but yet because I have little else to communicate, I shall observe yr comands. The Body or Skeleton of it is a sermon I preach't above 30 years agoe at S. Maries church in Cambridge upon 2 Pet. 3. 11. The heads of ye Discourse are 1. The Testimonies of Scripture concerning the Dissolution of ye World. 2. The Testimonies of ye ancient Christian Writers. 3. The Testim. of the Ancient Heathen Philosophers & Sages. 4. An answer to the following Questions.

1. Whether there be any thing in nature that might prove & demonstrate, or argue & inferre a future dissolution of ye World; & heer I mention & handle four probable or possible means of such a dissolution. 1. The possibility of the waters returning again to cover ye earth. 2. The possibility of ye extinction of the sun. 3. The possibility of ye eruption of ye centrall fire. 4. The possibility of a deflagration in ye torrid Zone.

2. Whether this Dissolution shall be effected by natural or by extraordinary means, & what they shall be.

3. Whether shall ye Dissolution be gradual or suddain.
4. Whether shall there be any signs or forerunners of it.
5. At what period of time shall ye World be dissolved.
6. How far shall ye Conflagration extend: whether to ye Etherial Heavens with all ye host of them: Sun, Moon & Stars; or to ye Aereal only.
7. Whether shall ye Heaven & ye Earth be wholly dissipated & destroyed, or only refined & purified.

Besides, there are two large Digressions, one concerning ye general Deluge in the days of Noah: another concerning ye Primitive chaos & creation of ye World. In the former of those at ye instance & importunity of some friends I have inserted something concerning formed stones as an effect of the Deluge, I mean their Dispersion all over the Earth. Therefore you will find all I have to say in opposition to their opinion, who hold them to be primitive productions of Nature in imitation of shels. I intended to have reserved them for your work, but they extorted them from me, upon pretence that my Discourse would be imperfect without them; & that no man who hath written heertofore concerning ye Deluge hath made any mention of them; & therefore such an addition, for ye novity of ye matter would be acceptable to ye curious, & give my book advantage of sale.

Your Discoveries in ye subject of formed stones are very remarkable & instructive. Methinks what you have now found out should a little stagger & unsettle you in ye opinion & belief that they are original productions in imitation of the shels & bones of fishes. I will not suggest what I know must needs occurre to your thoughts upon contemplation of ye fossile oysters you discovered. I never heard of any parts of crustaceous fishes found in England among other fossile shels. I have seen in *Museums* beyond sea the entire fishes petrified.

All ye knowledge I have of Mr. Woodward is from your letters. In a former letter I remember you told me that Mr. Beaumont had written agst Mr. Burnet's theory of the Earth wch he intended to print. I doe not yet hear that it is come abroad, I pray tell me in your next, whether you have any further news of that work.

For Mr Edward Lloyd
at the [old] Ashmolean Museum in Oxford.

Thomas Burnet, Clare 1651, fellow of Christ's 1657–78; Master of the Charterhouse 1685, †1715. Burnet worked out his *Sacred Theory of the Earth* 1690 in very great detail. He disagreed with those of his contemporaries who considered that the garden of Eden was between the Earth and the Moon, for he was sure it lay in the southern hemisphere near the tropic of Capricorn.

> He knew the seat of Paradise,
> Could tell in what degree it lies;
> And, as he was disposed, could prove it
> Below the moon, or else above it.
>
> Butler, *Hudibras.*

The work was a fine, historical romance. Yet such was the uncritical attitude of that day, that it was received by most folk as profound science, and was lauded both by Steele and Addison.

'Even Milton had scarcely ventured in his poem to indulge his imagination so freely in painting scenes of the Creation and Deluge, Paradise and Chaos. He explained why the primeval earth enjoyed a perpetual spring before the flood; showed how the crust of the globe was fissured by "the sun's rays", so that it burst, and thus the diluvial waters were let loose from a supposed central abyss. Not satisfied with these themes, he derived from the books of the inspired writers, and even from heathen authorities, prophetic views of the future revolutions of the globe, gave a most terrific description of the general conflagration, and proved that a new heaven and new earth will rise out of a *second chaos*—after which will follow the blessed millennium.' (Lyell.)

Forty years later the work was severely criticized by Keill, whose *An examination of Dr. Burnet's Theory* was distinctly unsympathetic.

Another writer who made a considerable stir at the time was William Whiston, the mathematician, of Clare Hall. Born in Leicestershire in 1666, he became chaplain to the Bishop of Norwich in 1695, and in 1701 was recommended by Newton as his successor in the Lucasian Chair

As a fourteen-year old child his imagination had been greatly stirred by the great comet of 1680 and the possible

power of such celestial visitants. When he became acquainted with Burnet's *Sacred Theory of the Earth*, published in 1690, he elaborated a new theory of the Deluge by assuming that on 18 November 2349 B.C. an enormous comet came so close to the earth that its tail, coming in contact with the equator, shook out waterspouts and attracted the subterranean waters from the depths of the earth, causing them to inundate the surface and destroy all. All this romance he gave to the world under the title of *A new theory of the Earth; wherein the Creation of the World in Six days, the Universal Deluge, and the General Conflagration as laid down in the Holy Scriptures, are shown to be perfectly agreeable to Reason and Philosophy*, 1696.

We need not deal with his other remarkable flights of fancy. As a skilled mathematician he had the art to throw an air of plausibility over the most improbable side-issues, while seeming to be proceeding in the most sober manner. He followed Burnet in placing the Garden of Eden in the southern hemisphere under the Tropic of Capricorn. He supposed that in the beginning of the creation the earth had no rotatory movement about its axis: that did not begin until after the Sin and Fall of Man in Paradise. After the Fall by reason of the rotatory movement, the internal heat of the earth radiated towards the surface, and there encouraged a rich increase of plant and animal life, but also caused a strong development of human passions. The punishment was the Comet and the Flood. Never had so many inexplicable things been reconciled by one theory supported by mathematical demonstrations.

Many people, who knew no better, loved it all. Locke praised it to the skies. But after a time Keill put an unsympathetic finger on its glaring absurdities, while theologians found Whiston's interpretation of the text of Genesis so much at variance with their traditional interpretation that they could only regard his work as heterodox. Already in 1699 Ray had read the theory, and criticized it as 'pretty odde and extravagant, and is borrowed of Mr. Newton in great part'.

On 25 April 1728 JOHN WOODWARD, M.D., of Pembroke College died, leaving a will (dated 1 Oct. 1727) under

which a Geological Professorship was founded in Cambridge with the intent to oppose the theory of Camerarius, that fossils were not of organic origin.

My Will is, that my Executors, as soon as conveniently may be, do purchase lands, tenements, and hereditaments in fee-simple, situate, lying and being in some good part of South Britain, of the yearly value of one hundred and fifty pounds; and that after such purchase made, they do convey and assure the same to and upon the University of Cambridge: I mean, the Chancellor, Masters and Scholars of the University, for ever, in such manner and form, and by such proper terms and conveyances, as councel learned in the law shall for that purpose advise and direct; the sum of one hundred pounds thereout to be paid yearly and every year to a Lecturer, to be chosen, for the purpose herein-after specified, by my executors, the survivors or survivor of them; and from and after their decease, by the Lord Archbishop of the province in which the said University of Cambridge is, who, it is to be presumed, besides his favouring of learning and all useful knowledge, will think himself under obligation to have special regard to this University; and, for still the same reason, by the Lord Bishop of the diocese, in which the said University is, by the President of the College of Physicians, and by the President of the Royal Society of London, by the two Representatives, or Members from time to time elected and serving in Parliament for the said University, by the whole Senate, (that is to say) the Chancellor and Vice-Chancellor of the said University, the Provosts, Masters and Heads of the several Colleges and Halls for the time being; the Doctors, Masters of Arts, and all who have a right of voting for Members of Parliament, representing the said University; or a majority of the above specified illustrious and excellent persons. And it is my request to them, that in consideration of the benefits which may thence accrue to the public, they will be pleased to take upon them the care and guardianship hereof; and that they will make choice only of such men for reading the Lectures herein after specified and directed, as have distinguished themselves by their learning, their virtue, their judgment and great abilities. And in case that it shall happen by reason of age, sickness, or absence from the University, the said Archbishop, Bishop, Chancellor, or

either of the two Members of Parliament, or of the two Presidents above-mentioned, cannot be present and give their attendance at the time that any election is to be made, it is my will and intention, that any of these electors, so absent, may appoint a proxy to assist and give a vote at that election. And I Will that the first Lecturer be chosen as soon as may well be after my decease, and that all the succeeding Lecturers be from time to time chosen after each vacancy or removal of the predecessor or former Lecturer, within the space of two months at farthest; the Vice-Chancellor causing public notice to be timely given by billets fixed up in the Public Schools, and by advertisements printed in the Gazette, or some other like authentic public newspaper. And my Will is that none be chosen but bachelors, or men that have not been married, and in case of the marriage of any of the said Lecturers afterwards, his election shall be thereby immediately made void, lest the care of a wife and children should take the lecturer too much from study, and the care of the Lecture. And my Will further is, that if a divine shall at any time happen to be a competitor with a layman for this Lectureship, in case the latter shall be as well qualified, he shall ever have preference of the former; not out of any disrespect to the Clergy, (for whom I have ever had a particular regard) but because there is in this kingdom better provision, and a much greater number of preferments for the clergy, than for men of learning among the laity. And my Will is, that all such Lecturers shall from time to time be further subject to such rules, orders and directions (not interfering with those herein-after particularly specified and set forth) as the electors, or a majority of them shall from time to time think fit to make. And my Will is, that no one shall at any time be chosen Lecturer who then hath any preferment, office or post whatever, that shall any ways so employ or take up his time as to interfere with his duty herein set forth, and particularly that shall require his attendance out of the University. And in case any of the Lecturers after he is chosen shall accept of any such preferment, office or post, his election shall be thereby made void, and another chosen in his room. And it is further my intent and meaning, and I do hereby Will and order, that such Lecturer from time to time so to be appointed and chosen by my executors, the survivors and survivor of them, so long as any of them shall be living, and after-

wards to be chosen by a majority of these excellent and illustrious persons above-mentioned, shall reside in the said University of Cambridge, and never be absent from the same above the space of two months in the year, and those to be in the long vacation in the summer. And that the said Lecturer shall there read at least four Lectures every year, at such times and in such place of the said University as the majority of the said electors should appoint, on some one or other of the subjects treated of in my Natural History of the Earth, my Defence of it against Dr. Camerarius, my Discourse of Vegetation, or my State of Physick, at his discretion; but in such language, viz. English or Latin, as shall be appointed from time to time by the Chancellor, Vice-Chancellor, Provosts and Masters of the several Colleges and Halls belonging to the said University, the said Lectures, or at least one of them, at the Lecturer's own free choice and election, to be published in print every year.

ITEM, I give and bequeath my original Collection of English Fossils, contained in two of my Cabinets marked with the several letters A. and B. and also the said two Cabinets with the Catalogues of the said Fossils, which I have drawn up, to the said University of Cambridge. AND my Will is, that as soon as may well be after my Decease, my executors or the survivor of them, do cause and procure the same to be lodged and reposited in such proper Room or Apartment as shall be allotted by the said University, to the satisfaction of my executors or the survivor of them. AND my Will further is, that the said Lecturer from time to time to be chosen, shall have the care and custody of all the said Fossils, and the catalogues of them, and that he do live and reside in or near the said apartment so to be allotted for repositing the said Fossils as above-mentioned in the said University; and that he be actually ready and attending in the room where they are reposited, from the hour of nine of the clock in the morning to eleven, and again from the hour of two in the afternoon till four, three days in every week (except during the two months in the long Vacation, wherein he is allowed to be absent as above mentioned) to shew the said Fossils gratis, to all such curious and intelligent persons as shall desire a view of them, for their information and instruction; and that he himself shall be always present when they are shewn, and take care that none of the said Fossils are mutilated or lost. AND I desire the said Chancellor, Vice-Chancelior,

Provosts and Masters of the several Colleges and Halls, or a majority of them, that before the admission of every Lecturer and likewise afterwards once every year, they do appoint two discreet and careful persons who shall inspect and examine the said Collection of Fossils, and compare them with the catalogues; of which I Will, that besides those to be kept by the Lecturer, there be copies reposited in the Public Library of the said University, for greater security, that the said Fossils be preserved with due care and faithfulness; and that the said two persons to be appointed to inspect and examine the same, shall give under their hand a report of their examination thereof, their comparing them with the said catalogues, and the state and condition in which they are kept, and whether any of them are lost or mutilated; for which their care and trouble, I desire and direct that five pounds a piece be annually paid them out of the estate in fee above directed, to be purchased and conveyed to the uses and trusts of this my Will. AND to the end that the said Fossils may be preserved and kept with the greater care and faithfulness, it is my Will, that the Lecturer and keeper of them from time to time shall before his admission give such security as my executors and the survivor of them, and after the decease of such survivor, the succeeding electors shall think proper. AND I further Will that the sum of ten pounds shall be yearly and every year paid to the Lecturer above-mentioned, out of the rents of the said estate in fee, to be laid out and employed by him, from time to time, in making observations and experiments, keeping correspondence with learned men on the subjects directed to be treated of in the Lectures, and in procuring additions to the Collections of Fossils, or in which of them each Lecturer for the time being shall think fit; he rendering annually to such of the electors as shall be in the University an account in writing in which of the ways the said sum of ten pounds hath been employed and disbursed. AND I further Will and direct, that out of the annual rents of the said estate in fee, the sum of ten pounds annually for ever be appropriated and allowed for Dinner on the first day of May; or if this fall on a Sunday, then on the second day of May, for the said Lecturer, two Inspectors, or Examiners, and the said Chancellor, Vice-Chancellor, Provost, and Masters of the said Colleges and Halls of the said University; to the end that they may then consider of methods to improve the design and use

of the said donation by me hereby made. And I greatly wish that these things that are of so much use and importance, and which I have with great diligence and expence collected, may by this settlement, the care of the electors, and the diligence of the Lecturer, be made serviceable to the setting forth the wisdom of God in the works of Nature; to the advancement of useful knowledge, and to the profit and benefit of the public. And it is my further Will and intention, that the surplus and residue of the annual rents of the said estate in fee, after the salary to the Lecturer, the ten pounds per annum to the two inspectors or examiners, the ten pounds per annum for correspondents and experiments, and the ten pounds per annum for the dinner first paid and satisfied; I say that all the surplus and residue of the said annual rents shall go and belong to the said University for ever, for the payment of taxes, or any other necessary contingencies. But in case any surplus should remain, after such taxes and contingencies paid, that then such surplus be disposed of yearly and every year, in such manner as the said University shall think fit: but in hopes, that for the honour of the University, and the benefit that will thence accrue to the public, if the design of this donation be rightly carried on; that the said University will be pleased to dispose of the said residue in making experiments and observations, in correspondence, in natural collections, books, or other things that may serve to the promoting the good ends of this donation. But in case the said taxes should at any time amount to more than the said sum of twenty pounds, being the residue of the said sum of one hundred and fifty pounds hereby bequeathed to the said University; then my Will and intention is, that the Lecturer shall pay such overplus of the said taxes out of his said salary. And further it is my will and intention, that any Lecturer not doing his duty, and acquitting himself rightly to their satisfaction, shall be removable at the discretion of the electors or the majority of them, and another chosen in his place; his salary to commence from the quarter-day next ensuing the death or removal of his predecessor. And I do hereby order, will and direct that the above-mentioned salary of one hundred pounds per annum, herein-before limited and appointed as a provision for the said Lecturer, be paid and satisfied to him from time to time by four even quarterly payments, at and upon the four usual feast days or days of payment in the year; (that is to say)

the Feast of the Annunciation of the Blessed Virgin Mary, the Nativity of St. John the Baptist, the Feast of Saint Michael the Archangel, and the Nativity of Christ; and in case of default of payment of the said sum of one hundred pounds per annum, for his salary, and the sum of ten pounds per annum, for the uses above-mentioned out of the said lands, or estate so purchased and conveyed as above specified, to the Lecturer to whom it shall become due, by the space of six months after any of the days of payment whereon it is directed to be paid as aforesaid: it shall and may be lawful for that Lecturer to distrain for such arrears of his said salary: and if there be not sufficient by such distress to pay himself the said arrears, that he shall and may sue for them, and enter upon the said estate settled for support of the Lecturer, and hold and keep the same till his arrears be paid, or till he accept another place or office or be absent from the University, or neglect to read or print the Lectures as is herein for that purpose particularly specified.

This will shows the testator to have been no ordinary man. A good though somewhat biased character-sketch of John Woodward at the age of 36 has been given by Uffenbach. Woodward was then living in London.

'In the afternoon [of 31 Oct. 1710] we again drove to Dr. Woodward's where we at last attained our object of seeing his things. He again after his manner kept us waiting for a good half hour in the ante-room, afterwards regretting that we had not arrived on the stroke and come half an hour earlier. This is the discourteous little ceremony that this affected and pedantic mountebank makes a habit of going through with all strangers who wait on him. He first showed us a considerable number of all manner of *lapidibus pretiosis* which are to be found here & there in England. After this we saw some *minerals* and then the *petrifacta*, which are the most elegant of all his collections. He had not a vastly amazing quantity of them but they were choice and handsome. We found especially curious the collection illustrating prodigiously elegantly the whole generation of shells from beginning to end in complete sequence. He had also many varieties of stones figured with all kinds of plants. Further shells encrusted with all manner of metals and minerals, part of them being also entirely filled with them. Among the latter were a large quantity of fine

cornua Hammonis. He had a cupboard filled with all sorts of urns and ancient vases. In another were large mineral snails and great *cornua Hammonis,* which were certainly handsome, though their size did not equal those we saw in Limburg at Herr Reimer's. In a cabinet he had a considerable number of manuscripts dealing with English Natural Philosophy, which, so he told us, he had for the most part written himself. As he shut this cabinet he said that he would now prove to us that he was not 'idle'. We could not immediately recall the meaning of the word in English and thought, from the pronunciation, that he meant to say that he was not *eitel* (vain). Since he was making such a boast of his own works we could hardly restrain our laughter.

Among these books was a volume in which he had all his Shells tolerably well drawn.

Here follows the paragraph on the Vegetable Sheep *printed on p.* 392.

'One has to listen ad nauseam to his opinions *de diluvio et generatione antediluviana et lapidum postdiluviana.* He recites whole pages of his writings, accompanying them with continuous encomiums. The most ridiculous thing of all is that he never ceases looking at himself in the mirrors, of which several hang in each room. In every respect he behaves like a female and an insolent fool. For a pedant he is much too gallant and elaborate. He is a man in the thirties, unmarried, but criminis non facile nominandi suspectus. Very ridiculous stories are told of him, and Herr Erndel gave a most diverting account of him in his Epistle *de itinere Anglicano.* This angered him greatly, and he is continually railing against this German. It is thought that for this reason he has taken a dislike to Germans and raises a great many difficulties about showing them his things, which was certainly our experience.'

The truth of this character-sketch is confirmed by the testimony of Stukeley, who credited Woodward with 'a great deal of knowledge in most parts of learning, but so blended with the most egregious coxcomb, as scarce to be paralleled'.

At his death in 1728 he bequeathed his systematic collection of English specimens contained in two cabinets A. and B., to the University of Cambridge, where it is still

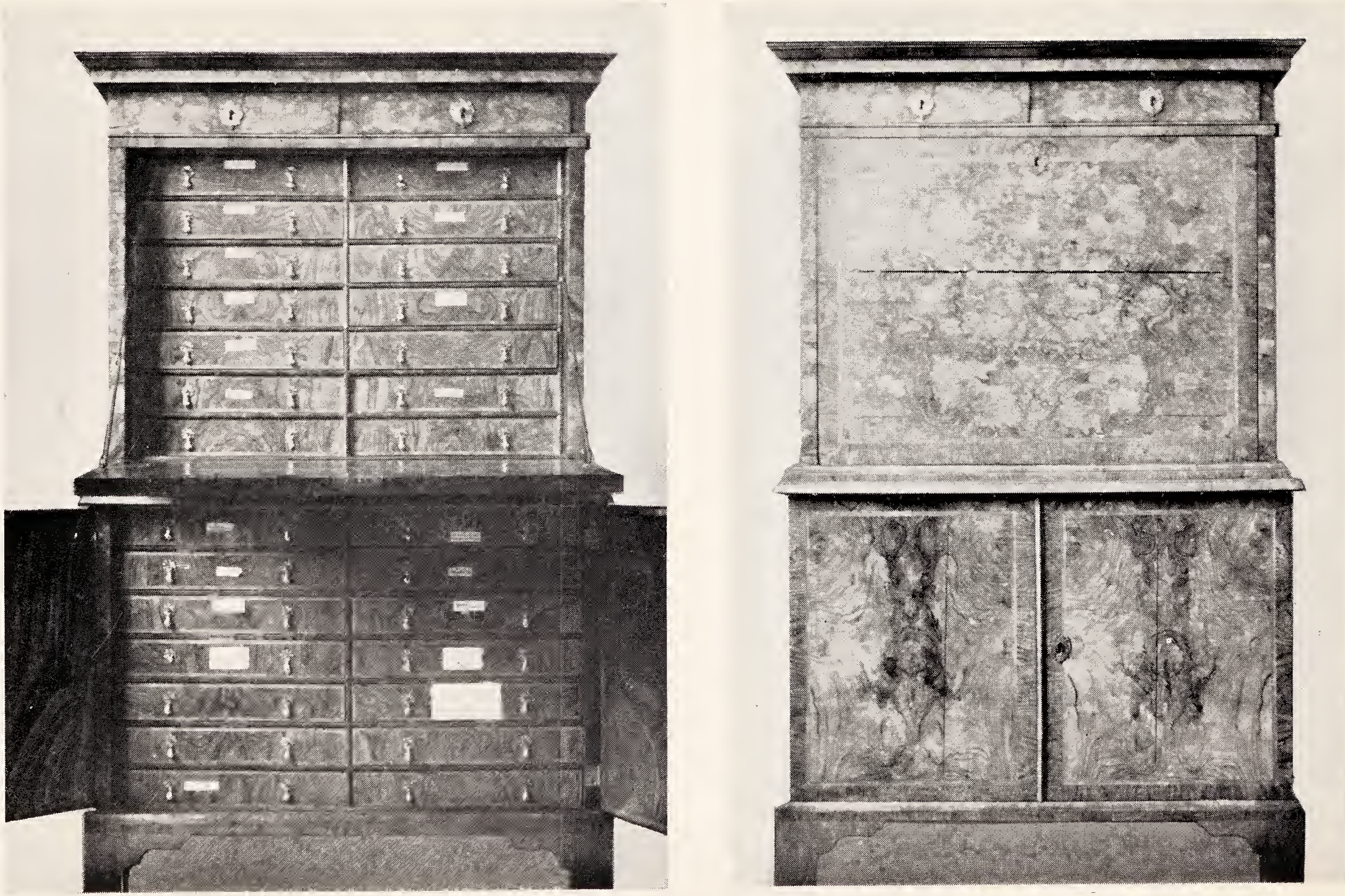
preserved as arranged by him, and shows how far he had advanced in ascertaining the order of superposition of many of the British strata. Two other cabinets C. and D. containing English and Foreign specimens, he ordered to be sold, but they were saved by purchase by the University for £1000.

A catalogue, containing a surprising body of precise data of geological localities, &c., was printed in 1729. It remained the only general work on fossils in English for nearly a century, when it was supplanted by J. Parkinson's *Organic Remains of a Former World*.

It is curious that there should be no mention of so great a benefactor in Schuster and Shipley's *Heritage of Science*.

The Woodward professor was expected to deliver four

lectures a year in Latin or English, and to publish one of them, also to attend at the Museum and to give oral instruction 'to all such curious and intelligent persons as shall desire a view of them'. (*Facetiae Cantab.*, pp. 151–2.)



WOODWARDIAN CABINETS

315. The Woodwardian Collection of Minerals, Fossils, and Rocks. 1729.

Sedgwick Museum.

The Museum Woodwardianum is contained in five cabinets, 'A, B, C, D, E,' 5 ft. 6 in. high by 3 ft. 6 in. wide. Each cabinet contains thirty drawers in two tiers, enclosed by doors. They are housed in a special enclosed study at the east end of the Sedgwick Museum of Geology. The collection includes those of Edward Brown, Scheuchzer, Doody, Stonestreet and others.

316. Fossil Jaw of Zeuglodon. 1747.

Woodwardian Collection.

This specimen is one of many collected in Malta by Agostino Scilla, the Sicilian painter, who in 1747 published a treatise in which he emphasized the striking resemblance of fossil to recent forms. It is figured by Scilla in his *De Corporibus marinis*, Tab. xii f. 1, and is therefore an object of special interest. See fig. on p. 432.

The first Woodwardian Professor to be appointed was CONYERS MIDDLETON, D.D., of Trinity in 1731. He published an *Oratio de novo Physiologiae explicandae munere ex celeberrimi Woodwardi Testamento instituto, habita Cantabrigiae in Scholis Publicis a Conyers Middleton S.T.P., Acad. Cant. Protobibliothecario et Lectori ibidem Woodwardiano*, c. 1732, but retired in 1734, being succeeded by CHARLES MASON, D.D. (Trin.), known as 'a practical engineer of a queer character'. His *Oratio Woodwardiana* appeared in 1734. He died in 1770, leaving materials for a map of Cambridgeshire.

The third Woodwardian Professor was JOHN MICHELL (Queens' 1742), 1762–4, who had previously reported on the strata between Cambridge and York, proving the crust of the earth to be stratified. (*Phil. Trans.* 1760.) In the same year appeared his epoch-making *Essay on the Cause and Phenomena of Earthquakes*, also published in the *Philosophical Transactions*.

Five years previously the sympathies of Europe had been directed to the victims of the great earthquake of Lisbon in 1755. Michell put forth many original views respecting the propagation of subterranean movements,

and the caverns and fissures where high pressure steam might be generated. By such causes he explained the contortions and fractured state of strata in the vicinity of mountain-chains. His evidences were mostly derived from personal examination of the rocks of Yorkshire. His paper was illustrated by a diagrammatic section through a mountain system, showing a central core composed of the crystalline rocks, and on either side a succession of uptilted and upheaved strata, covered in their turn by younger and less tilted strata. This figure may have suggested to Pallas the views that he subsequently elaborated on Mountain Chains (1777). Michell resigned the professorship in 1764, and died in 1793 aged 69. (D.N.B.)

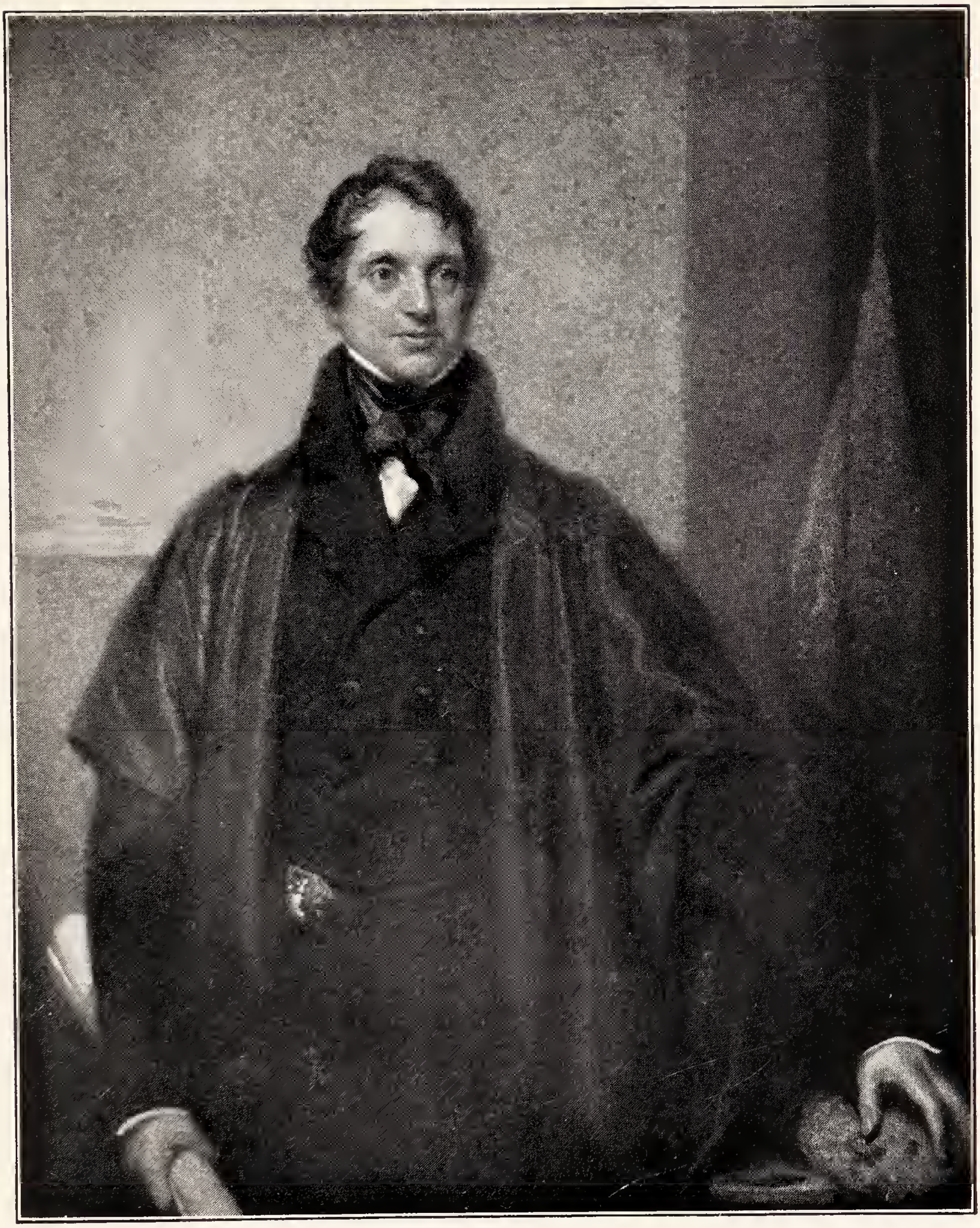
The fourth Woodwardian professor was SAMUEL OGDEN of St. John's, noted as a preacher and as the subject of several amusing stories.

His fondness for good living is illustrated by the story that he used to say of a goose that it was a silly bird—too much for one and not enough for two.

A cherry tree that he had planted in his garden bore for the first time, but one day, missing some of the fruit, he accused his house-boy. 'I have not touched them as true as God's in heaven.' 'That's a good lad, sit thee down & I'll give thee a glass of wine, for thou wouldest not tell me a lie.' Going to his cupboard he put a strong dose of tartar emetic into the wine and gave it to the lad, who presently showed discomfort and wanted to leave the room. 'No, set thee down, thou wilt soon be better'; and sending for a jug of warm water, made him drink it. Whereupon the cherries soon made their appearance—'Where's the God in heaven? Thou miscreant, get thee out of my house!'

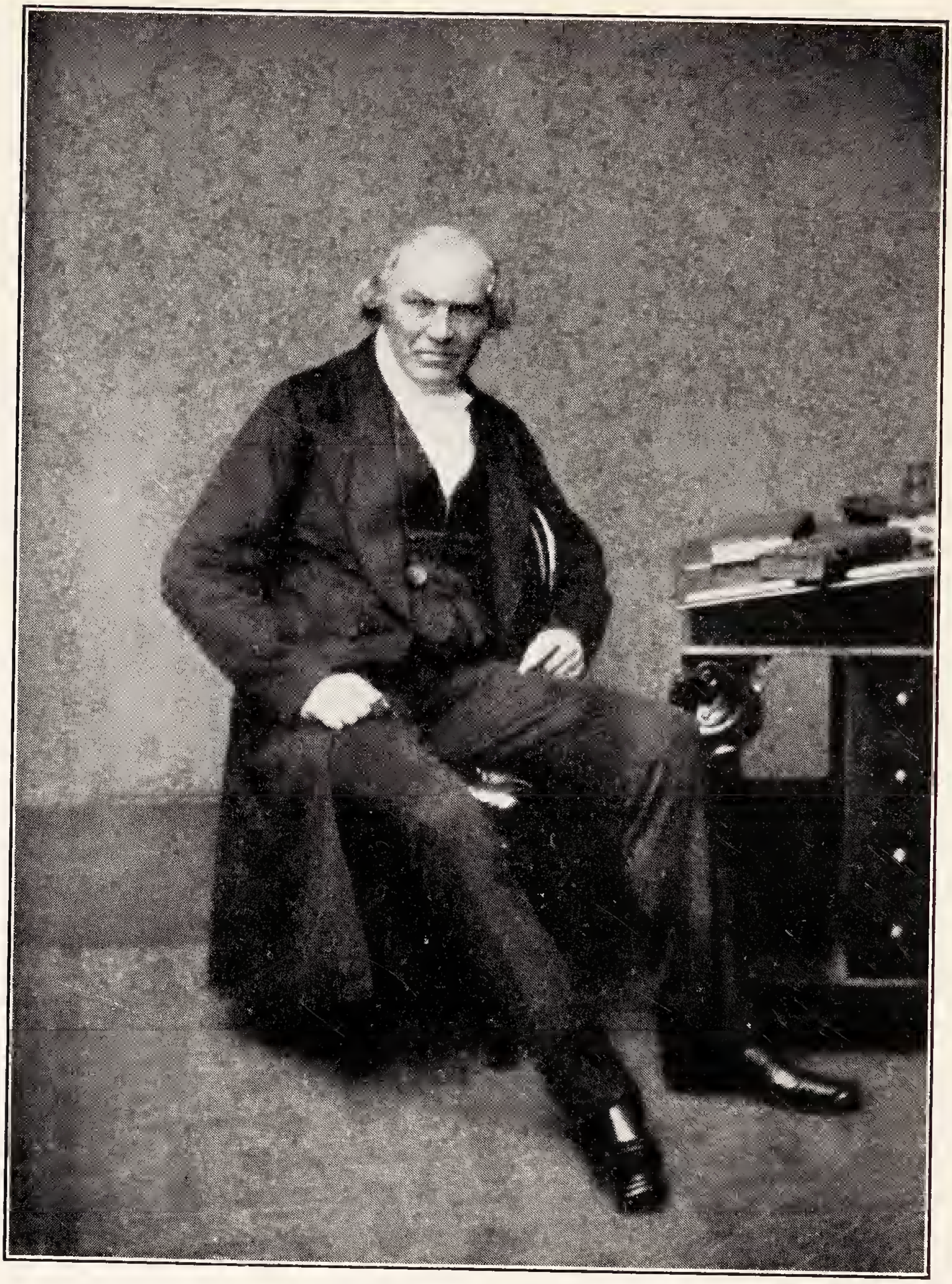
Ogden was followed in the Woodwardian Professorship in 1778 by No. 5, THOMAS GREEN of Trinity, who took in hand the arrangement of the collections and books. On his death at the next election on 28 June 1788 JOHN HAILSTONE, M.A., fellow of Trinity, beat the Rev. Thomas Newton, M.A., fellow of Jesus College, by 127 votes to 43. *Cambr. Chronicle*, 5 July 1788.

Hailstone combined a knowledge of botany and archaeology with that of geology. He seems not to have lectured much, but to have shown the collections to all comers for four hours twice a week. He made a collection distinct



ADAM SEDGWICK

By courtesy of the British Association



WILLIAM WHEWELL

By courtesy of the British Association

from Woodward's and published *Outlines of the Geology of Cambridgeshire* in 1816.

At his death in 1818 there were again two candidates for the post. George Cornelius Gorham, fellow of Queens', the biographer of the Martyns, who had some knowledge of geology, and Adam Sedgwick of Trinity, who had none, but undertook to 'get it up'. Sedgwick polled 186 votes to Gorham's 59.

And right well Sedgwick succeeded, proving a most stimulating teacher both in the classroom and in the field. He was born on 22 March 1785 at Dent in Yorkshire, had studied theology and mathematics at Trinity, becoming an assistant demonstrator in 1809.

A born teacher, his lectures, full of enthusiasm and relieved by a ready sense of humour, stimulated many of the younger men to devote themselves to geology. In July 1822 he started his geological researches in Cumberland; in 1826 made his first long journey with Roderick Murchison to Scotland, and worked for ten years with him until a difference of opinion about the Cambrian rocks embittered their friendship.

For a short time William Whewell began to make a serious study of Geology. He accompanied Sedgwick in 1821 to the Isle of Wight and in 1824 to Cumberland, 'rambling about the country, and examining the strata'. In 1831 he reviewed Lyell's *Principles of Geology* and succeeded him in 1837 as President of the Geological Society, the year in which his *History of the Inductive Sciences* was published.

Sedgwick's studies of the fossils of the Plymouth limestones resulted in the separation of the vast group of rocks from the overlying Carboniforous and the underlying slates. This group is now known as the Devonian System. The true nature of *cleavage* was elucidated in his paper *Remarks on the Structure of large Mineral Masses* (Geological Society, 1835).

Further, stimulated by the work of Jonathan Otley in Cambria, and with a personal acquaintance with the rocks of West Yorkshire from childhood, he was attracted by the charms of a wild and almost unexplored country. He threw all his energy into the work of unravelling the succession of stratified rocks exposed in the mountains of Cambria.

To him Geology owes the name Cambrian for the oldest known beds of fossiliferous rocks.

With Murchison he described the arrangement of the Tertiary beds 'unconformably stratified' against secondary formations in the Alps. *Trans. Geol. Soc.* iii.

Through Sedgwick's liberality the Woodwardian, with the Fletcher, Leckenby, and Walton collections, became a museum of which Cambridge was justly proud. Its scientific value was greatly praised when the Wollaston and Copley medals were conferred on him.

Sedgwick died on 27 January 1873.

Peterhouse also had a choice selection of specimens gathered and arranged with loving care by the late Master, whose love of science and forethought have also left a mark on the Woodwardian Museum. (Wordsworth.)

In 1843 it was pointed out that the erection of the Mineralogical Museum, the new Anatomy Schools, and the provision of fittings for the Observatory had so diminished the funds of the University that the appointment of a syndicate of enquiry was expedient.

During the 'forties and 'fifties the Geological collections were one of the sights of Cambridge. C. G. Carus wrote of them with approval in 1844

> Not far from the church is the Mineralogical and Geological Collection, neither is very large. The latter contains some very interesting specimens, among the rest a large fossil deer, an admirably preserved Plesiosaurus, above 9 feet long; and what for the first time I had seen in such perfect form, several specimens of Spiriferae, fossil shells, first described by Buckland, which between their valves contain a kind of skeleton or detached spiral, whose physiological value has not been yet clearly determined. C. G. Carus.

Again in 1847 on July 7 the Woodwardian Museum was visited by the Prince Consort, who again in 1853, on November 22, with the Chancellor, accompanied by H.R.H. the Duc de Brabant, visited Cambridge and attended the Rev. Prof. Sedgwick's Geology Lecture.

At that time the Woodwardian estates for the support of the Geological Museum and Salary of the Professor yielded £348 *2s. 2d.*

'Two specially geological chapters in the *Origin of Species*, 1859, have always seemed to me to form DARWIN'S most momentous contribution to the philosophy of geology.' So wrote Sir A. Geikie, P.R.S. They are entitled *Of the Imperfection of the Geological Record and Of the Geological Succession of Organic Beings.*

JOHN EDWARD MARR, 1857–1933, fellow of St. John's, began as an undergraduate to make a special study of the Lower Palaeozoic rocks, which enabled him to compare these, the oldest fossiliferous deposits, with those of Bohemia and Scandinavia. For his *Classification of the Cambrian and Silurian Rocks*, 1882, he was awarded the Sedgwick prize. Among the more noteworthy of his later papers were those on the early rocks of the Lake District, North-West Yorkshire, Cross Fell, Shap. The lakes and tarns of Lakeland doubtless stimulated the production of his chief physiographical work *The Scientific Study of Scenery*, a most readable and attractive volume.

In 1886 he became University Lecturer on Geology, and in 1917 succeeded Prof. Hughes as Woodwardian professor. As a teacher he was beloved by many generations of undergraduates, most of whom 'came as pupils and left as devoted friends'.

WOODWARDIAN PROFESSORSHIP, 1727

1.	CONYERS MIDDLETON	1731
2.	CHARLES MASON	1734
3.	JOHN MICHELL	1762
4.	SAMUEL OGDEN	1764
5.	THOMAS GREEN	1778
6.	JOHN HAILSTONE	1788
7.	ADAM SEDGWICK	1818
8.	THOMAS MCKENNY HUGHES	1873
9.	JOHN EDWARD MARR	1917
10.	OWEN THOMAS JONES	1930

XVII

MINERALOGY

The earliest printed works on Minerals by a Cambridge man were the notes contained in his treatise on the Waters of Bath by William Turner, the herbalist, of Pembroke Hall, an outline of whose career is given on page 368. This work was printed in 1577.

A full century later a work on precious stones was composed by Thomas Nicols of Jesus College, son of Dr. John Nicols, M.D., 1594, in practice in Cambridge (Masters, *Hist. of C.C.C.* 349). It was founded on the *Gemmarum Historia* of Anselm Boetius de Boot, and stones are classified by sizes. It appeared under three titles

(1) *A Lapidary: or the history of Pretious stones: with cautions for the undeceiving of all those that deal with pretious stones.* By Thomas Nicols, sometimes of Jesus Colledge in Cambridge. Pr. by T. Buck, printer to the universitie of Cambridge 1652.

(2) *Arcula Gemmea: a cabinet of jewels. Discovering the nature, vertue, value of pretious stones, with infallible rules to escape the deceit of all such as are adulterate and counterfeit.* London: pr. fr. Nath. Brooke 1653.

(3) *Gemmarius Fidelius, or the faithful lapidary, experimentally describing the richest treasures of nature in an historical narration of the several natures, vertues and qualities of all pretious stones. With an accurate discovery of such as are adulterate and counterfeit.* By T.N. of J.C. in Cambridge. London; pr. for Henry Marsh 1659. [Cf. Mr. Bolton Corney, *Gent. Mag.* n.s. xvii, 594.]

The study of Mineralogy was recommended by NEWTON, who believed that thereby valuable information might be obtained concerning the transmutation of metals.

'Observe the products of nature in several places, especially in mines . . . and if you meet with any transmutation out of their own species into another (as out of iron into copper, out of any metall into quicksilver, out of one salt into another, or into an insipid body, &c.), these above all, will be worth your noting, being the most luciferous, and many times luciferous experiments too in philosophy.'

A great impetus to the study of Mineralogy was given by the publication of Dr. JOHN WOODWARD'S *Catalogue of the English Fossils* in his Collection. It was contained in his *Attempt towards a Natural History of the Fossils of England*, 1729. Part I dealt with 'the Fossils that are real and natural' (i.e. the Minerals and Rocks, as we should now call them), which he further classified as 'Earths, Stone, Marble, Talcs, Coralloids, Spars, Crystals, Gemms, Bitumens, Salts, Marcasites, Minerals, and Metals'. Of these he recognized 1,574 separate kinds, distinguishable by their nature and properties, 'so far as the most rigorous examinations and the exactest experiment I could make, laid them open before me'. In every case he was careful to record the history and provenance of each, 'at what Depth and in what manner it lay . . . as also in what plenty; also its various medicinal, mechanical or other uses'.

This collection he bequeathed to the University, with the 'extraneous fossils, parts of Vegetables & Animals, digg'd up out of the Bowels of the Earth'.

JOHN MICHELL, who had been a lecturer at Queens' College on Hebrew, Arithmetic, Geometry, and Greek, held the professorship only from 1762 to 1764, when his career was suddenly cut short by preferment to a benefice. From that time he appears to have been engaged in clerical duty, to the exclusion of scientific pursuits, exemplifying the working of a system where the chairs of Scientific subjects, being frequently filled by clergymen, the reward of success disqualifies them, if they conscientiously discharge their new duties, from farther advancing the cause of science,

and that, too, at the moment when their labours would naturally bear the richest fruits. (Lyell.)

In February 1807 a better beginning was made by EDWARD DANIEL CLARKE of Jesus, who gave lectures on Mineralogy under the auspices of Professor Hailstone, and on December 15, 1808 became Cambridge's first Professor of Mineralogy. Clarke was also remembered for his travels in Europe and the nearer East and as the discoverer of the Eleusinian 'Ceres' or Caryatid.

On his return from the Grand Tour in 1802 he spent some months in Paris where he became acquainted with several of the members of the Institute, and especially with the Abbé Haüy, whose lectures in the Botanic Garden he attended. Haüy also gave him private instruction in his theory of crystals. On his return home Clarke composed a small work on Mineralogy for students, 'small & pleasant for travellers', 'by which I hope to make mineralogists, as fast as Bolton makes buttons'. It was, however, not published. By permission of Thomas Martyn the lectures were delivered in the Botanical Lecture room.

The subject was little known, and less studied, at the University, when Clarke gave his first lecture. 'Above 200 persons were in the room. There was not room for them all to sit. I worked myself into a passion with the subject, and so all my terror vanished. I wish you could have seen the table covered with beautiful models for the Lecture.' (*Letter* of February 19, 1807.)

'We will wile away a few minutes over the beautiful specimens which are so delicately arranged upon the table and the surrounding cases, from the primitive formation of granite to the costly stones and precious metals; the [gas] blow-pipes too, [his own invention], whose intense heat in fusing metal has so much assisted the science; the picture of the grotto of Antiparos, with its beautiful stalactites and crystal floor; the ingenious section of the strata of this island; the green god of the New Zealanders; and a vast collection of curious and precious things . . . His earnest manner of recommending his darling pursuit shows that his heart and soul are wrapt in it. To a full audience he mentions the names of some ambitious travellers among his pupils who have brought him specimens

from Scandinavia, Switzerland and the Pyrenees. (*Facetiae Cantab.*, p. 153.)

The syllabus for the lectures is believed to have been drawn up by J. Holme of Peterhouse, but the professor's enthusiasm made it impossible for him to confine himself to his friend's outline; and as his departures from the programme were marked by much brilliancy of eloquence, the greater part of his hearers considered them as the most valuable part of the lecture. He was called '*Stone* Clarke' to distinguish him from his colleagues, *Bone* Clark, professor of anatomy, and *Tone* Clarke, professor of music.

The Oxyhydrogen Blowpipe and the great heat of its flame were the subjects of many experiments by him about 1816, and an improved pattern, the celebrated Gas Blowpipe, was designed for his use by Newman of Lisle Street in London. In consequence of an accidental explosion, which might have done him more injury than the loss of eyebrows and eyelashes, the Professor of Chemistry—Cumming, interposed a 'safety cylinder' with an oil trap. By exposure to the intense heat of this blow-pipe it was believed for a time that he had isolated the metal from Barytes. He gave the name Plutonium to this 'solid metal of the colour of silver'. (Thomson, *Chemistry*, v. i, p. 342, edit. 1817.) During the later six years of Clarke's professorship ineffective rivalry was attempted by Farish, the Jacksonian Professor, including a lecture on 'the natural history of minerals' to his already overburdened course on chemistry. See p. 230 (*University Calendar*, 1814). His minerals were purchased for £1500.

Clarke died on 9 March 1821, and on 15 May 1822, the Senate passed the following grace

> Cum per mortem Edvardi Danielis Clarke, nuper Professoris Mineralogici munus istud jam vacans existit; Placeat vobis ut alius ad idem munus exequendum a nobis eligatur.

A squabble arose over the method of election of a successor and a Report on the Mineralogical Professorship was published in 1824 by Henry Gunning, M.A. (Christ's), which resulted in the procedure in elections to *Professorships of Mineralogy, Botany*, and *Anatomy* being referred to Sir John Richardson for settlement

Six pamphlets were written thereon.

In 1827 Sir John Richardson made the subjoined Award:

To the Vicechancellor of the University of Cambridge.

Sir,

In pursuance of the Letter, addressed to me by the Chancellor, Masters, and Scholars of the University of Cambridge in Senate assembled, sealed with their common seal, and bearing date the 22d day of December, 1825, (wherein, after reciting that a difference of opinion had arisen in their body respecting the Election of Professors of Mineralogy, Botany, and Anatomy, they requested me to determine, after having heard Counsel, the manner in which these Professors should in future be elected,) I have accepted the reference thereby made to me, and have been attended by Mr. Alderson and Mr. Amos, the Counsel of the several parties, and have heard such arguments, and perused and examined such papers and evidences, as they thought proper to lay before me respecting the matters in difference; and now having maturely considered the same, I request you to make known to the Chancellor, Masters, and Scholars, this my opinion and determination on the premises, that is to say:

First. I am of opinion, and so determine, that although the University has from time to time appointed several Professors of Anatomy, Botany, and Mineralogy, and in several instances has in so doing apparently assumed that such offices continued to exist after the death of the last Professor, yet in fact, whatever has been hitherto done on each and all these occasions has amounted to no more than to temporary provisions, each made for the particular appointment at that time contemplated, and which had not the effect of binding the University to continue the office, or to appoint another Professor after the next vacancy; consequently, that the University has not yet founded or established any permanent Professorship, either of Anatomy, Botany, or Mineralogy; and that no such permanent offices do at this time exist.

Secondly. I am of opinion, and so determine, that either strangers, with the previous or subsequent consent of the University, or the University itself by Grace or By-Law, may, ad Eruditionis amplificationem, found and establish permanent

Professorships in Anatomy, Botany, or Mineralogy, or in any other branch of Science or liberal Learning, and may, by the terms of the foundation prescribe any reasonable mode of Election, which they may deem most proper; and that by so doing they would not infringe the Statutes of the University made in the twelfth year of the reign of Queen Elizabeth.

Thirdly. I am of opinion, and so determine, that if the University, or any Stranger, should found any new Professorship, and should not by the terms of the foundation provide any particular mode of Election, the case would then fall within the provisions of the fortieth Chapter of those Statutes, (that 'De nominatione et electione Lectorum et aliorum officiariorum,') and that the Elections must be made in conformity therewith, according to the mode prescribed by the thirty-fourth chapter of the same statutes (that 'De electione Pro-Cancellarii').

Fourthly. I am of opinion, and so determine, that the words 'a vobis eligatur,' or other equivalent words, used in a Grace submitted to the Senate, are not sufficient to prescribe any particular mode of Election; such words being in my judgment equally satisfied by an Election made with, or without, previous nomination; which election is in neither case made by the Senate assembled in houses, but by the members of the Senate voting individually; and therefore, that in cases where an election is made in pursuance of a Grace so worded, and where no particular mode of Election is otherwise prescribed, the mode of Election must be governed by the fortieth chapter of the Statutes before cited.

In witness whereof I have hereunto set my hand this first day of December, 1827. John Richardson.

By his invention of the Reflecting Goniometer W. Hyde Wollaston provided the student of crystallography with his most important and most accurate instrument of research. The morphology of crystals depends upon the angles at which the faces meet, and the accurate measure of these angles by Wollaston's method enabled Mitscherlich to pronounce with certainty the Law of Isomorphism which has changed the whole aspect of chemistry, even as Wollaston's gift of the platinum crucible provided laboratory workers with one of their most valued tools.

The Wollaston Medal commemorates the benefaction of W. H. Wollaston to the Geological Society.

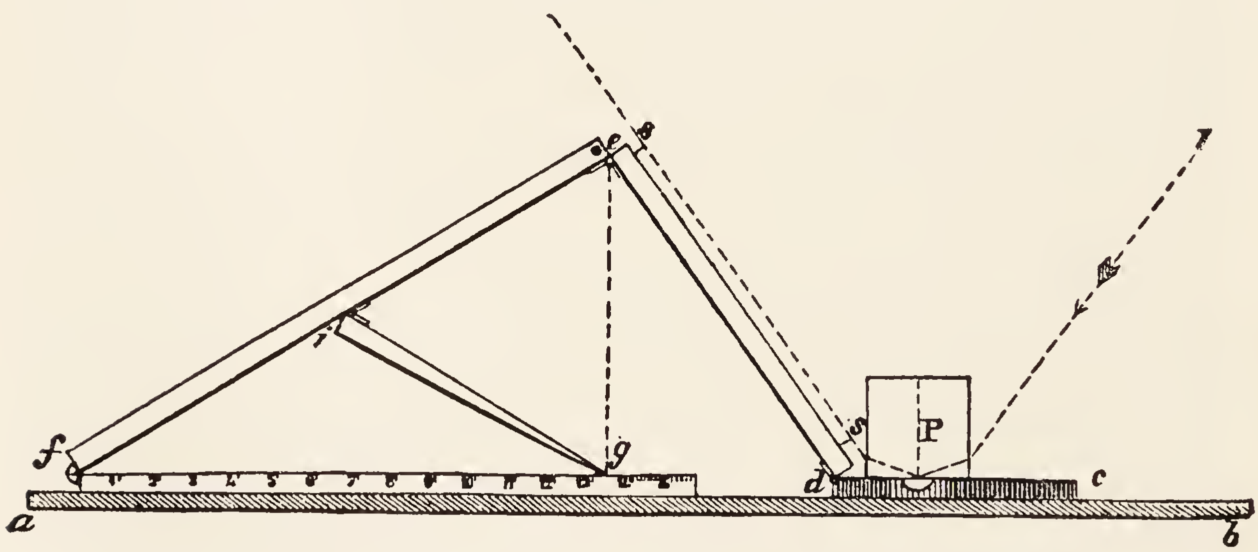
In 1828 WILLIAM WHEWELL was elected Professor and published an *Essay on Mineralogical Classification and Nomenclature*, but his interests were geological rather than mineralogical, and too diversified to permit him to give any one subject undivided attention. He felt overworked and resigned the Professorship in 1832. One of the *Reports on Mineralogy* published by the British Association was from his pen.

WILLIAM HALLOWES MILLER (1801–80) was elected to the Professorship in 1829, three years after he had graduated as fifth wrangler. He devoted his mathematical knowledge to the elaboration of a new system of Crystallographic notation which became generally adopted owing to its simplicity. Mr. Storey Maskelyne in 1876 considered that there is no system that represents the *face* of a crystal so completely, and is so simply and so readily converted into a mathematical expression as that which Miller has given us.

GONIOMETERS IN THE DEPARTMENT OF MINERALOGY

317. Total Reflectometer. 1802.

FIG. 75.



Designed by W. H. Wollaston, *Phil. Trans.* 1802. Belonged to Sir G. G. Stokes. Base-slide 3 ft. long. It was designed to give the refractive power without calculation.

318. Two-circle Goniometer. 1874.

Constructed by Prof. W. H. Miller in 1874, 15 years before the publication of similar instruments by v. Fedorov Goldschmidt & Czapski. A vertical circle of $4\frac{1}{4}$ inches diameter by 'Cary London' has been fitted to a horizontal circle (diam. $7\frac{7}{8}$ in.) by 'Troughton & Simms'.

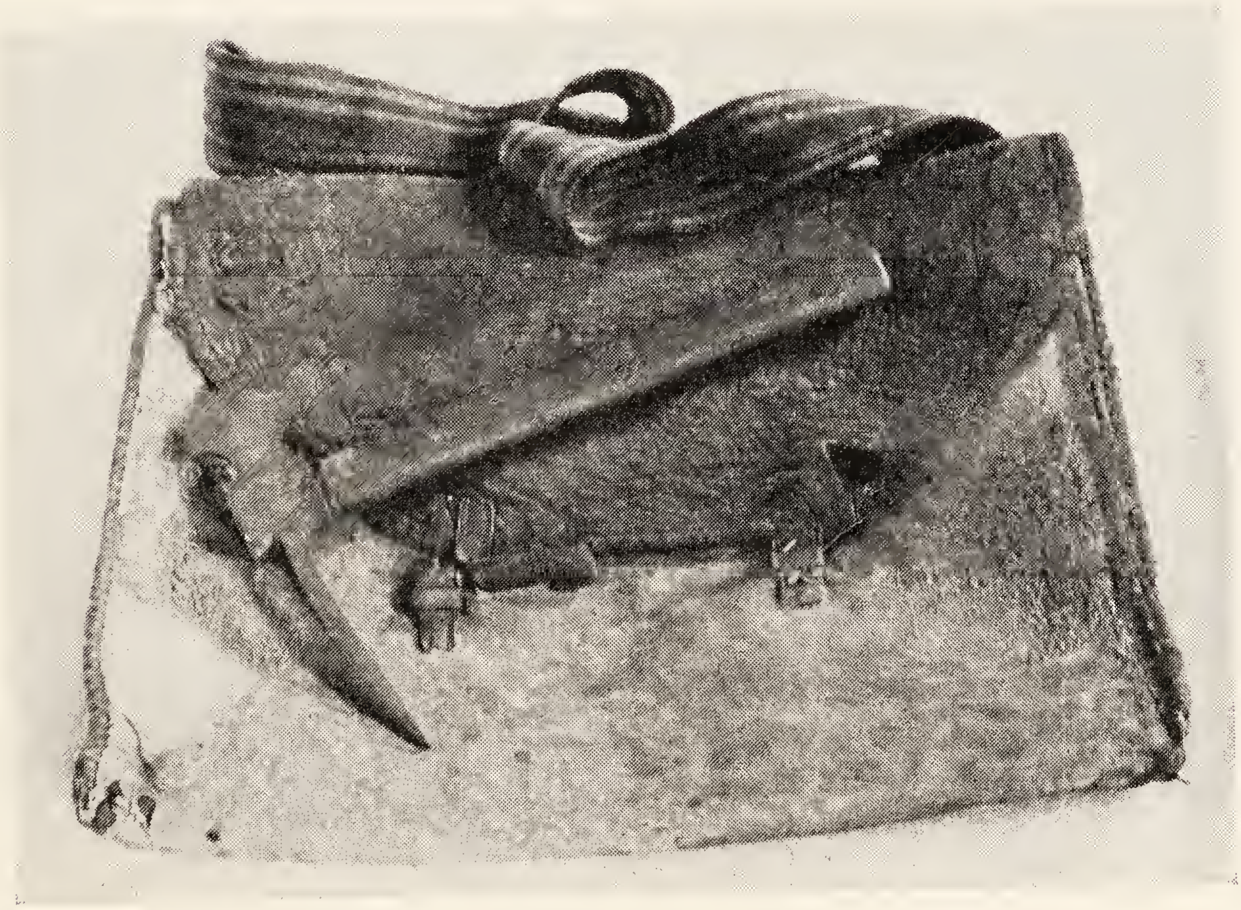
319. Hand Goniometer of $1\frac{1}{2}$-inch radius. c. 1835.

In red leather case inscribed 'W. H. Miller'. Fitted with two sets of removable radial arms. The invention of Carangeot.

320. Apparatus for approximate Measurement of Crystals. c. 1840.

Designed and made by Prof. Miller, of L-shaped wires and corks, for use when no goniometer was available.

Professorship of Mineralogy, 1808	
1. Edward Daniel Clarke	1808
2. John Stevens Henslow	1822
3. William Whewell	1828
4. William Hallowes Miller	1832
5. William James Lewis	1881
6. Arthur Hutchinson	1926
7. Cecil Edgar Tilley	1931



Prof. A. Sedgwick's Bag and Hammer.

APPENDIX A

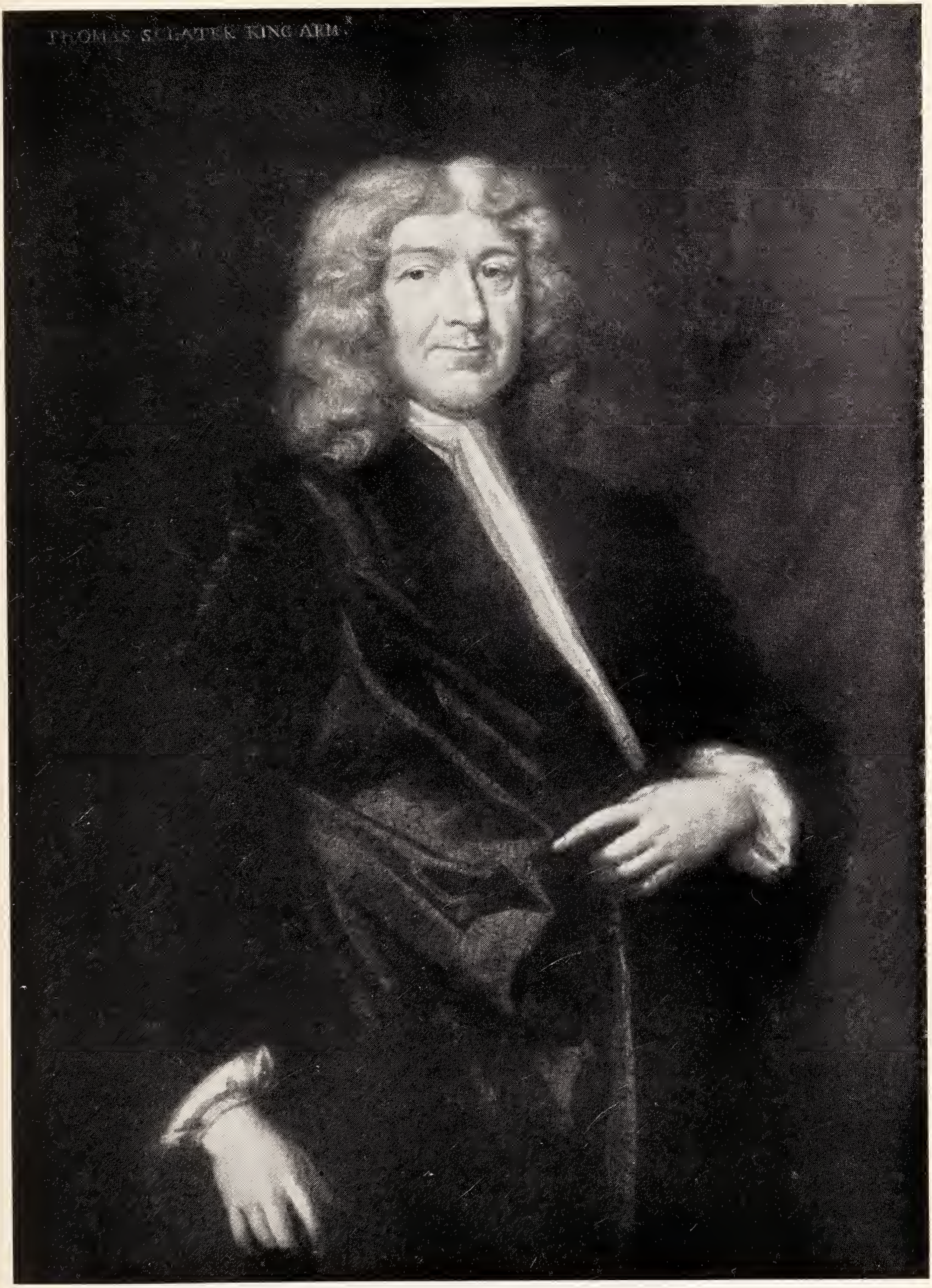
FRUIT AND FISH CULTURE BY SIR THOMAS SCLATER AT CATLEY PARK IN CAMBRIDGE-SHIRE, 1674–81

While engaged in tracing manuscript materials likely to shed light upon the history of forgotten English Botanists of the seventeenth century, I was fortunate enough to discover an early book of Gardening Records which illustrate the actual gardening practice of a member of the University and a benefactor of Trinity College, at a particularly interesting period, when attempts were being made to introduce certain cultural methods, that had been worked out with some success in Oxfordshire, into the Eastern counties which were stated to have then been in a very backward state in the matter of fruit-growing.

Among the Swyncombe deeds was a quarto note-book of older date entitled 'Catley and Linton Book' but without the name of the writer. The style showed it to have been the private memorandum and account book of the owner of that property, and the date pointed to its being the work of Sir Thomas Sclater—an identification which is confirmed by the identity of the handwriting with that of the *Memorandum Book kept by Sir T. Sclater Bart—of warrants and committals made by him as J.P. for Cambridge 1660–67*, now MS. Rawlinson C. 948 in the Bodleian Library.

The importance of this carefully kept account of gardening experiences at that time is apparent from the following circumstances.

About the middle of the seventeenth century people were striving to make good the serious losses which the country had suffered as the result of the Civil War, and



SIR THOMAS SCLATER

From the portrait in Trinity College

many and various were the expedients that were proposed to restore the wasted wealth of the nation. Of the various schemes few were more popular than the planting of trees for building, fuel, and other uses, and especially the planting of orchards. A catalogue of the fruit-trees grown in 1644 by the Rev. Walter Stonehouse in Yorkshire, which may be taken as a fairly representative selection of fruits actually grown in a garden of the time, has already been printed in the *Gardeners' Chronicle* for June 12, 1920. Several contemporary Treatises on Fruit culture issued from the Oxford press, such as Ralph Austen's *Treatise on Fruit Trees shewing the Manner of Planting, Grafting, Pruning and ordering of them in all respects, according to the Rules of Experience* of which a first edition was printed in 1653, a second in 1657, and yet a third in 1665; and Francis Drope's *Short and sure Guide in the practice of raising and ordering Fruit Trees*, 8vo, Oxford 1672, show that at least in Oxford the advantage of scientific fruit growing was being fully realized. The spread of the new cult was slower in East Anglia. The state of affairs is well described by John Beale, F.R.S., in letters addressed to the Worthy Henry Oldenburg, Secretary to the Royal Society and printed in London in 1677 under the title *Nurseries, Orchards, Profitable Gardens and Vineyards encouraged, The present Obstructions removed, and probable Expedients for the better Progress proposed: For the general benefit of his Majesties Dominions, and more particularly of* Cambridge, *and the Champain-Countries, and Northern parts of England.*

In a prefatory letter to this work Beale observes that 'The great example of his Majesty, and of our Nobility, and generally of our chief Gentry, hath prevailed from the East all over the West, so far as to encompass *Oxford*. And the stop is said to be about *Cambridge*: And here (i.e. *in Beale's book*) are those Expedients proposed, which may be effectual to remove all Obstacles. And if the Gentry about *Cambridge* shall be pleased to accept of them, and henceforth to be stirring in the business, as is here directed, they may soon overtake all that's done about *Oxford*, and advance more in five years, than hath hitherto been done in twenty, Though it is not little that hath been done of

late. For these Arts, and our Experience, and more Expedients also, do grow daily'.

The first letter in the book is contributed by Anthony Lawrence. In it 'some plain Nursery-Books are recommended; with Encouragements and Expedients proper to promote the planting of Nurseries and Orchards in the Champain-Countries near Cambridge, Leicester &c.'.

After commending the various horticultural works by Ralph Austen, who described himself as a '*Practiser in the Art of planting Fruit trees* for at least 50 years' (1626–76), and who had but recently taken in a further 27 acres of ground to enlarge his former Nurseries near Oxford, Lawrence proceeds to explain that there is at least one of his friends who would gladly celebrate, in the best manner he can devise, 'the Names and memory of those who shall have the happiness to do good in the same kind for *Cambridge*, as *Mr. Austen* hath done and still continues to do for *Oxford*. And the merit will be signal: For, besides the Amenities and other Advantages of health, and sweet Air, when *both Universities* shall be invested in a Golden Grove, it will have a good influence to allure the like improvements in all parts of *England*. . . . And if *Cambridge* should be the Example, it would, without doubt, excite very great improvements towards the *North*, and in many Countries about the Heart of England. For if any Expedient can invite the Champain-Countries, that are about *Cambridge*, to Inclosures, I think, Orchards, Gardens, Nurseries, and Groves, are most likely to do it; these yielding Quick-sets and other most profitable materials, to enable and encourage for Inclosures; and Gardens every year repaying a full reward'.

Thomas Sclater was the son of William Sclater, born at Halifax in 1615. He matriculated at Sidney Sussex College, Cambridge, in 1631, and became successively a Scholar and Fellow of Trinity College (1637). Like many others, he was ejected from his Fellowship during the Civil War, read medicine, and on 13th June 1649 took the degree of Doctor of Medicine at Oxford about the time when John Goodyer and his botanical friends were gathered together in that city.[1] It may be that he subsequently practised medicine

[1] Gunther, *Early British Botanists*, 1922, p. 79.

at Cambridge for a while, until the chance of marrying a wealthy widow came to him. According to Dr. Palmer[1] the lady, the relict of Dr. Thomas Comber, the ejected Master of Trinity College, was either very wealthy or very charming—but surely a Cambridge lady may have been both—and they were married in February 1653. They lived in Cambridge. In 1659 he was elected M.P. because he was a 'gremiall', a 'gentleman very well known by many of us to be a very ingenious person of very good abilities'. He was pricked for Sheriff in 1660, and died in 1684.

In 1675 he purchased the Linton Estate of the last representative of the Paris family whose monuments dated 1502–1680 may be seen in the parish church. The estate lay about 10 miles south-east of Cambridge and consisted of the manors of Great and Little Linton together with the manor-farms of Chilford and Michaelots. On the estate was a park, Catley Park, with a large mansion-house which was pulled down soon after 1771 when the property passed by purchase to Edmund Keene, Bishop of Ely, who took its internal decorations to the Palace at Ely and whose lineal descendent, Miss Ruck-Keene, is the present Lady of the Manor and therefore successor to the very extensive privileges, e.g. right of free-warren, power of life and death, &c., formerly enjoyed by the Lords of the Manor of Linton Magna.

The horticultural interest of Sir Thomas Sclater's 'Catley Book' lies in the fact that not only are all details concerning the management of his estate noted with the most meticulous care, no trifle being too insignificant to be omitted, but that its entries are dated from 1674 to 1682, and thus just cover the years during which Cambridge was exhorted to wake up to the possibilities of fruit-growing.

To Mrs. Ruck-Keene I am indebted for permission to cull the following extracts from this treasure-house of gardening practice.

Operations were begun in November and December 1674 by the planting of two orchards by Alexander Cockle of Babram, gardener. In Linton Orchard were planted 158 trees obtained from Captain Girle of London.

[1] Dr. W. Palmer, *The Reformation of the Corporation of Cambridge*, July 1662. *Cambridge Antiq. Soc. Comm.*, xvii, 1914.

Peare Trees 17

The Sumer & winter Burgomite.	Malberry.
The winter muske.	Greenfield.
Pound peare.	English & French Wardens.
The painted peare.	Perkins Warden.
The Nonsuch.	Black Peare of Woster.
The Windsor.	vid.libr.F.2 p.210 Cockles hand.

Aples Trees 60.

Sumer & winter pearemanes.	French Pippen.	Kentish Peppen.
	Sumer Pippen.	Russett pippen.
Golden peppin.	Harvey.	Gilloflower.
Golden Russetties.	Golden Russett.	Genestin.

vid. libr F 2° p. 110 of their prices & Cockles acquittance.

Cherrie Trees 78.

vid. libr F 2° p.110 of their prices & Cockles acquittance. In all trees planted there with y^e plum trees below—225 att 1^s a tree one with another.

Plume Trees 3

The additional charges paid in November 1674 included:

Nov. 74. Charges vid. my book for ye accounts of Lynton Tenants	
Fetching new pales & a gate fro. Lynton 1 large load	00 · 01 · 6
Fetching 6 load of wood from Lynton wood for ye Hedge for ye New Orchard	00 · 15 · 0
6 loades of hedging wood valued att	0

At the same time Catley Orchard was planted by Cockle with 67 trees from Babram.

Peare trees 12

Summer & Winter Burgomies. Orange Burgoing. Red Katherine. Winter Muske. English & French Warden. Greenfield: Windsor.

Aple trees planted 53.

The sortes:—Summer & winter pearemane. Baford. Russet pippin. Kentish peppen. French pippen. Harvey Spencer pippin. Aple John.

Cherries trees 2

In all there were planted 225 trees 'att 1^s a tree one with another'.

11th Jan. 1674 paid 11^{li} - 01 - 0 to Cockle.

At the beginning of the next planting season on 18 Oct. 1675, Goodman Grumball measured the inward walls of the garden at Catley and found them to comprise about 315 feet of south wall, 250 feet of south-west wall and 222 feet of north-east wall. These were to be planted as follows:

1. The front of y^e Howse viz y^e inward wall from ye Dovecoat to the Corner where there was a litle Brick Howse is all a *South* wall to bee planted with peaches, Apricock & Nectarines being in length in all 10 pole besides the door & 10 foot distance for every tree, in all 31 trees viz. Apricok trees 9 Peaches 9 Nectarines 8 Vines 5.

2. The wall within y^e Orchard is a South wall & is in length sevenscore & 10 foot to bee planted with Apricocks Vines & Peaches & a Vine betwixt each tree.

i. Apricocks of Orange A. 3, Roman 3, Turkey 3.
ii. Peaches viz. Newington, one early & i late. 2 Smirna 1 Redd Nutmeg Peach & 1 White Nutmegg Peach. 1 Queenes P. 1 Rambullion 1 Sion peach.
iii. Nectarines 8. viz 3 Roman y^t are redd. 3 Eldridge. 2 Sadl.

3. The wall from ye   to ye Litle Stable, to the Crosse wall. A South west wall & is in length to ye Crossewall 90 foot to bee planted with peares, plums, cherries, vines; 2 Vines & 9 other trees.

i. Cherries. 1 Carnacon. 1 White Hart. 1 Duke.
ii. Plums. 1 Queen Mother. 1 Muscell plum. 1 black Damasen.
iii. Peaches. 1 Orange Burgomate. 1 Winter boon Creton. 1 black peare of Worcest.

4. The wall from y^e Dovecoat towards the Brewhouse is in length to y^e brick particon wall 90 foot & is North East: will hold xi trees viz plumes & Morelloes.
Plums:—1 Violett. 1 Queen Mother. 1 redd. 1 black Damazens. 2 Muscell plume. 1 white date. 2 morelloes.

5. 2 Crosse Walls on each side of ye Howse are each of them in length 66 feet besides y^e door & well hold 6 trees of a side & is North East & are for plumes & cherries hei morelloes & flanders plums, 2 white peares. & 2 black, 4 morello, 2 white Damazen, 2 Bele Magdalen.

6. Ye wall by ye Mote or pond: its eight score foot in length & is south west & will take 15 trees besides ye door plant itt with cherries viz May cherries, Dukes, Black Harts, White Hart, redd Hartes.

7. Vines planted on y^e Howse. Vines 7 viz. on y^t side towards the orchard 3 & on ye front 2 vines a piece on each side ye door viz 3 redd muscadine & 2 white muscadine.

An entry in the following month shows that trees were planted by Joseph Garrett of Bumstead at Sir John Bendishes and that the prices paid were—

Nov. '75	9 Apricocks	2^s 6^d	01 · 2 · 6
	7 peaches	3^s	01 · 1 · 0
	2 peaches	4^s	00 · 8 · 0
	8 nectarines	4^s	1 · 12 · 0
	24 cherries	1^s	1 · 4 · 0
	16 plum trees	10^d each	13 · 4
	12 Vines	1^s each	12 · 0
	3 peares	[1^s each]	3 · 0
	or '2^s 6^d a piece round one with another'		
			6 · 15 · 10

Jan '75 planted by Jos: Garrett [in Catley Garden].

22 peare trees att 1^s 2^d	01 · 5 · 8
10 aple trees 1^s a piece	00 · 10 · 0
8 dwarf cherry trees	00 · 08 · 0
100 gooseberry & cherry trees & curran trees at 3^d	1 · 05 · 0
6 aple standards 6^s	
20 Rose trees 4^d a piece	00 · 06 · 8
20 Laurels att 4^d	00 · 06 · 8
3 wall cherries	00 · 03 · 0
1 Apricock	00 · 02 · 6
1 Roman red Nectarin	00 · 04 · 0
	4 · 11 · 6

Dwarf Aple trees	6 att 1^s	06 · 0
Cherry trees 3	1^s apiece	03 · 0
peare trees 2	1^s 2^d apiece	2 · 4
Spanish Broom 6 next ye Crosse Door to ye Barn		1 · 6
		12 · 10

Jan '75. Fruit trees, &c. planted by Jos. Garrett of Bumstead in Essex, gardiner [in Catley Orchard].

Codling trees 200 att 6^d a piece planted in 3 Borders, viz.

1^{st} the border before y^e Brick wall.

2^d the border next the new quick from y^e Dovecoate to that end of y^e orchard & Brick hett & Cowle Acre & hath.

3^d the Border on y^e opposite side from the Brew Howse towards Catley grove & Cowle acre att 6^d a piece 5 · 00 · 0

Jan 75 planted by Joseph Garrett as followeth

Raspes 600 att 8^s *p* 100 all planted in 3 Borders next to y^e Codling trees upon all y^e 3 sides & inward in ye orchard att 8^s a 100 . . . . 2 · 8 · 0

Gooseberries & Currants planted Jan 75 by Jos. Garrett in ye orchard dispersedly att 3d a piece each—& ye number 120 come to . . . . . . 1 · 10 · 0

3 Jan. '75 paid Jos: Garrett Gardiner for fruite trees & Gardiner's work £7 7s 6d

In 1676 a considerable amount of planting was done by Joseph Garret, who appears to have been paid both for his labour and for plants and seeds.

24 Mar. 76.	To Jos. Garrett for work [in Catley Garden]	12 · 0
Apr. & May 76.	Sett and sowen by Jos. Garrett.	
	10 ounces of Matted Pink seed sowen	10 · 0
	Sweet Marjoram seed sowen	1 · 0
	Time seed	8
	Winter savory seed	8
	Issop seed	8
	Lettice parcely & spinage seed sowen	8
	6 dozen of primroses sett	12 · 0
	12 dozen of Stock gilloflowers sett	12 · 0
		1 · 17 · 6
	2 Tin waters potts 12s & carriage 3s	15 · 0
2 May 76	stock gilloflowers 4 dozen [for Orchard]	6 · 0
6 May 76	Seedes etc sowen in ye garden	2 · 12 · 8
26 May 76	32 daies work	3 · 4 · 0
28 Sept. 76	18 daies work for	2 · 4 · 3
Aug. 76	more stock gilloflowers planted or in ye garden, and pink seed ibi.	
Aug. 76.	1 great Rowle 17s & 1 lesser rowle for ye walk next ye pond 9s	[1 · 6 · 0]
Sept. 76	prune ye trees & wooding them—digging and turfing—use binding then for rose bushes.	

Oct 76 digging the Borders & digging moldes for the trees & making up the Borders, making Holes then for the trees to sett them att 1d of a Hole. Strawberrie then gathering a row roots att 4d a row.

Oct. 76. planted by Jos: Garrett in ye Borders of the best Strawberry roots 700 att 2s p. hundred	00 · 14 · 0
& 300 more of roots sent mee gratis by ye Gardiner at London	
& 4 figg trees 3s a piece	00 · 12 · 0
& 2 vines	00 · 03 · 0
& 48 Sweet Bryars att 6d a piece	1 · 04 · 0
In ye front walk in ye garden	
4 Honeysuckles planted there 1s 6d	00 · 06 · 0

Catley Orchard.

Oct. 76. Trees planted there by Jos: Garrett.

50 Dwarf trees in ye grasse plotts in ye severall plotts att 1s 6d a piece for the trees, his charges to London & charges to plant them . . . . . 3 · 15 · 0
And they are of these sortses.

Aples. 1. golding pippins. 2. Golding renits.
3. Holland pippins. 4. Pearemanes.
5. Great Runctons. 6. John Aples.
7. Lemon Pippin. 8. Harvy Aple.

Dwarf peares, planted now.
1. Virgator. 2. Amadets. 3. Metera John.
4. White Warden. 5. Oakenberry. 6. Greenfield.
7. Hamdens Birgamatt. 8. Mealala Bush
9. de ps 10. St. Michael.
11. Isanbert. 12. Burgomite.

Dwarf plums planted then
1. Matchless. 2. Deny peare.
3. Bona magn. 4. Musle.
5. Queen mother. 6. Prunella.
7. Imperiall. 8. Old Lenet
9. Damasin. 10. Pardigon.
11. Amber plum. 12. Damascins.

Dwarf Cherries planted.
1. Chequer. 2. Dukes. 3. Redd Carnacon. 4. Blackover Lenit. 5. Black Flanders. 6. Marello. 7. Early Flanders.

Oct. 76. *Standards.* then planted there 20 att 1s 6d as the dwarfes in ye next column come to . . . 1 · 10 · 0
& are planted in ye severall borders where others were deceased.
The Severall kindes of them are as followeth
1. Golding or Baford pippin.
2. Golding Rennets.
3. Pearemanes. 4. Nahan pippins.
4. Great russetting. 5. Kentish pippin.
6. John Aple.

Quince trees. 3 planted by ye Brewhouse Hedge, then by ye Brewhouse wall.
1. Warden. 1. Greenfield.

Quodlins now planted in ye border next ye Dovehouse 3 & 3 more in ye Border on ye other side next to ye Grove.

Standards in ye 1st row next ye Dovecoate 2 planted now
1. Warden. 2. Burgoing Peare.

In ye 2nd Row. 3.
1. Baford. 2. John Pippin. 3. Kentish peppin.
3rd Row. 3.
1. Baford. 2. Russetin. 3. John Aple.
4th Row.

1 Nahan pippin.
5th Border. 2.
1. Burgoing peare. 2. a peare mane.
6th Border. 2. 1. Baford. 2. pearmane.
7th Row 2. Both Baford pippins.
8th Border. 4. 1st 1. Gerton pippin. i pearemane. 2. wardens.

The Walk on the outside of the Moate is reckoned as part of ye Orchard.

Oct. 1676 Jos: Garrett ther planted 20 plum trees 1s 6d apiece 1 · 10 · 0
& 1 walnutt tree . . . . . . 0 · 2 · 4
20 Noveb. Setting plum trees and ashing—Bushing walnutt trees.

By this time it is evident that a certain stage had been reached in the planting of Catley garden, for under date 10 January 1676 he wrote a memorandum 'to find outt all my charge for Catley Garden & orchard see . . . in Index, in Cockle and Garrett, two gardeners, their 2 accounts there; and in Catley's index in ye parchment index'. And in another place he was able to write, '1676. The orchard and garden being all planted the Gardiner's work hereafter will bee

1st. to Rowle the walkes.
2. to kill the wormes.
3. to destroy the weedes.
4. to water the garden June & July.
5. to naile up the trees.
6. to prune the trees & take off the mosse: this & the last are performed in 14 daies in November & taking of ye mosse of from the trees killing the vermin. Orchard at Lynton lookt after, the ground digged, trees prund & muckt'.

Feb. 9. '76 dressing trees. Taking mowls in ye garden. 2 sheep skins then to naile ye trees att Catley 9d both.

March 17, '76 weeding the garden & clearing the orchard.

Apr. 14 weeding ye garden. Digging ye borders.

Apr. 27, '77 paid Jos. Garrett plum trees planted in ye walk by ye pond & pink seed etc. & work . . . . 3 · 6 · 9

May 7, '77 hee weeded the gravell walkes & kild the wormes and rowld them, naild up ye wall fruite trees yt were loaden with fruite, cutt ye grasse platts twice.
cutt all ye grasse in ye Gardens of ye orchard. Beddes of strawberries & raspe weeded: gutters in ye orchard cleansed. Kitchen garden lookt after.

16th Weeders att 6d a day.

June. '77 gathering stones out of ye new Kitchin garden.

Jun. 26. Weeding; mowing ye Orchard & rowling ye walke.

July 7 Watering trees & mowing. 2 skines to naile up wall trees.

July 29 Mowing ye garden & weeding.

Feb. '77 Kitchen garden sown.
Sowing seeds there by Jos. Garrett & after in Mar. 25, '77 & in May for Colliflowers . . . . . 4 · 3 · 10

Mar. '77. Docks in ye grass plotts rooted up with a by the weeders: walkes rowled etc, rowler greazd: Mowldes got out of ye ditches & lifted & laid on the borders & rakt whereby the yong weedes there are gott outt of the borders & ye stones & clotted mowldes taken of & rakt to ye sides of ye gravell & a man follows with a stick as broad as a lath to doe both after ye rake a 3rd man with a Beesom & skepp to take up ye moldes & gravell once in this time of ye yeare.

26 March 77. Rob. Hille's agreement for weeding, rowling, watering & mowing ye 2 gardens. libr. I 3°, p. 288.

In Christmas time very 12 daies & soe ye season will serve till Candlem. at Babram they cutt & naile all wall fruite: yt must be done by a knowing Gardiner least he cutt of all the bearers & leave the unfruitfull boughs: In Chrms time Jos. Garret was 6 dayes to prune & naile, & used 3000 nailes from Rob. Lawrence att . . .

Robt Hilles in 2 daies or 2 daies & a half will take of all mosse of ye trees att Catley Orchard & Little Lynton orchard for 3s or 3s 6d.

In Febr. or March the seedes are sowen for all such thinges as are sowd by seed ex gr.

Terras walk betwixt ye Somer House and Dovecoate.

Apr. '77. Jos: Garrett said itt would take trees to plant by the walles of shee Lawrell 50, & 6*d*, and 4 foot asunder, and Blackley will sette them att Mich.ls. for 2*d* a tree.

Next ye field firr trees 20, 3 foot high att 3*s* 6*d* a tree by Jos. Garrett & 2*s*. by Blackley.

19 Jun. '79 Jos: Garretts advice.

Cut the grasse early in ye yeare & weed the strawberries, rasberries etc & water them when its drie weather.

Water ye roots of trees in ye Garden & Orchard from the beginning or middle of June to ye middle of July once in ye week & cast 2 full watering potts upon the roots of every tree. In ye latter end of July & the beginning of Aug. is ye best time for me to be at Catley to have all fruits. Pease, strawberries & carrets are good & ripe the middle of June and the latter end.

Kill Jackdaws & Crowes with gunnes that eate cherries, pease & beanes.

Grasse in ye Garden & Terrace Walk.

Cut it the daie after the raine & sweep it presently off the

grasse & rowle the grave spot after. Grasse in the orchard to bee cutt earely & before itt bee too long & heat takes away ye Hart of the ground from the Tree.

In July and August 1679 Sir T. Sclater evidently took Garrett's advice and resided at Catley, for his account book shows that in those months he took an inventory of his fruit trees, carefully recording the position of each tree in Catley Great Garden.

31 Jul. 79. Fruite in ye Borders going out of ye Hall att ye Right hand Corner & soe going on ye Side towards ye Corner over against the great gate & from thence to ye Corner over against ye Dove Howse on ye Border of ye right hand till you return to ye 1st Corner over against the Hall Door.

1st on ye right hand till you come over against the great gate hath besides 2 Honysuckles, trees 3.

1. Windsor Peare. 2. Golden Russeten.
3. Violett Plum.

On ye Right hand from ye Corner over against ye front to ye Corner opposite to ye Dovehowse hath besides Currants Gooseberries Roses trees 6.

1. Winter Burgomite peare. viz ye Corner free.
2. Golden Runnett. 3. Green Choysell peare.
4. Windsor Pear. 5. Small Russetin.
6. Flanders Cherry.

Corner border over against ye Dove House to ye Corner over against the Crosse wall. hath trees 8 & gooseberries.

1. Corner tree Queenes Peare. 2. Winter peareman.
3. Orange Burgomite Peare. 4. Flanders cherry.
5. Margett Aple. 6. Primity Peare small . . .
7. Orange Burgomite Peare. 8. Flanders Cherry.

From the Corner Border over against the Crosse wall going or ye right hand to ye Corner Border over against the Parlor hath besides Gooseberries Currants Roses, Trees 3.

1. Sum̃er Burgomite. 2. Margett Aple.
3. Black Hart Cherry.

1st From ye Corner Border against the Parlor and to ye Corner opposite to ye Hall doore on ye right hand coming outt thence hath besides Curants gooseberries Roses Trees 6.

1st Hamburgh Burgomite. 2. Musk Aple.
3. Katherin Peare. 4th. Harvey.
5. Kyngs Katherin Peare. 6. Redd Hart Cherry.

Aug. 79 Names of fruite Trees by Jos. Garrett.
The names of all the fruite trees in the border of the great garden upon the left Hand . . . ing outt of the Left hand & soe

going to ye Corner opposite to the great gate. 2d the sum̃er house. 3rd the Howse of Office 4th the Corner of the Kitchen & soe return to the corner before the Hall to the left hand which hath besides gooseberries, currants & roses.

From ye corner on ye left hand opposite to the Hall to ye Corner over against the great Gates Trees 3 & 6.

1st to ye Corner Tree is Greanfield Peare.
2d Pearemane 3rd Redd date plum.
4th being the Corner Tree Mounsier John Pear.
5th a Harvey. 6. Sumr Burgomete.
7th a Katherin Peare. 8th Golden pippin.
9th Black Hart Cherry.

Corner Border from ye Summer House to the Corner opposite the House of Office. Corner tree first & soe on ye Corner before ye Hatths besides Currants Gooseberries & roses, Trees 17.

1st Corner tree opposite ye Summer house is Mounsier Johns Peare.
2d Figg Aple. 3. Violet peare.
4. Redd hart cherry. 5. Queen Aple.
6. Green choysell peare. 7. Sum̃er Boon Criton.
8. Black Hart cherry. 9. Sum̃er Burgomete Peare.
10. Gilloflower or Queen Aple. 11. Flanders Cherry.
12. Kyngs Peare att the Corner. 13. Golden Russett Aple.
14. Musk peare. 15. a poma Figg Aple.
16. being ye Corner tree is a Winter Burgomete.
17. a Duke Cherry.

Catley Great Garden to the front of the Howse Aug. 79.

Names of Fruit Trees by Jos: Garrett.

The Names of all the Trees & Fruite in ye walles of the garden beginning att the Hall doore & soe going from thence upon the right hand till you return to the great Gates. Sum̃er Howse House of Office Back of the Kitchin, Servants Hall to the Great Hall.

1. From the Hall doore going upon ye right hand to ye Crosse wall being a East Wall & North 3 vines. Midle Black Muskadin & 2 other white Muskadines.

3. From ye Crosse wall begining att ye end where the parlor is being a South east wall. Are trees to the Doore in the midle of the Crosse wall 3. & trees beyond the Doore in Crosse wall 3. viz 1. White Date plum cherries—3a. Muscle plum. 4th Muscle plum. 5. Morella cherry. 6. a crosse white Queen mother plum.

From ye wall on ye right hand adioyning & leading to ye Dove Howse & North West wall being eleven trees & a north west wall. viz.

1. Black prunello plum. 2. White date plum.
3. Violit plum before the door. 4. White Damasin plum.
5. Black date plum. 6. Black Damasin.
7. Morello cherry. 8. Black violet plum.
9. Belgon plum. 10. Morello cherry.
11. Violett plum.

From ye Great Front Gate to ye Sumer Howse upon the wall being a South west wall, 8 trees.

1. Smirna Peach. 2. Algier Apricock.
3. Navarr Peach. 4. Violett peach.
5. Turkey Apricock. 5. Newington Peach.
7. Musk Peach. 8. Turkey Apricock.

From the Sum̃er Howse to the Howse of Office being a South East Wall. are 10 trees viz.

1. Winter Boon Criton. 2. Morello cherry.
3. White Muskadin Vine. 4. Black Hart cherry.
5. Orange Burgomete Peare. 6. Duke cherry.
7. White— 8. Black Muskadin Grape.
9. Flanders Cherry. 10. Sum̃er Burgomite.
11. Black Hart cherry.

From the Howse of Office to ye Kitchin Wall being a North East Wall.

1. Morello cherry. 2. White Prunello Plum.
3. Violett plum. 4. Morello cherry.
5. White Violett plum.

The wall of ye Kitchen & Servants' Hall, being a North wall.
All Lawrell.
The front of the Howse before the Servants Hall being North wall.
2 Vines & Cluster Grape.
Catley Great Garden to ye Front.

From the Dovecoate to the great gates att the front is a South West wall & hath 8 trees v. Apricocks, Nectarines & Peaches.

1st a Murry Nectarin. 2. Roman Apricock.
3. Violett Peach. 4. Turkey Apricock.
5. Eldrege or Nectarin.
6. 7. Turkey Apricock.
8. Violet Muskate.

From the Corner of the Front on ye right hand before the Halles Parler is a South East wall & hath 3 white Muskadine Grapes & Rosemary & lawrel.

Catley Kitchen Garden.
Aug. 79. by Jos: Garrett ye names of fruite trees.
From ye Parlor or end of ye litle retiring Room being a South wall. 9 trees.

1. Eldreds nectarin. 2. Musk Peach.
3. White Nutmeg Peach. 4. Roman redd Nectarine.
5. Sadlers Nectarin on this side the door.
And next beyond the Door.
6. Rombullion Peach. 7. Roman red Nectarin.
8. Smirna peach. 9. Red Nutmeg peach.

The wall that reacheth to the Brew-howse is a West wall & hath 5 trees beginning from the wall above.

1. Newington Peach.
2. Early Apricock.
3. Violett Muscat Peaches.
4. Sion Peaches.
5. Sadler's Nectarin.

Catley Pond Walk.

Aug 79 names of fruit trees by Jos. Garrett.

Pond walk wall begining att ye Brew Howse or Dairy & soe goe to ye Stable is a South wall & hath 18 Trees.

1. Corneham Cherry.
2. Black Hart Cherry.
3. White Hart Cherry.
4. Black Hart.
5. a fegg Tree.
6. Redd Hart cherry.
7. Black Hart cherry.
8. White Hart cherry.
9. a figg tree.
10. Flanders Cherry.

The Doore in ye Middle.

11. Black Duke Cherry.
12. Flanders Cherry.
13. Duke Cherry.
14. Flanders.
15. Duke Cherry.
16. Black Hart Cherry.
17. White Hart Cherry.
18. Redd Hart Cherry.
19. On ye Stable white. Muskadin grape.

Catley Pond Garden.

Names of fruite trees Aug. 79 by Jos. Garrett.

Fruit trees there or Plum trees begining on the right as you come over the Bridge & next the Barn end.

1st Damasin.
2. White Queen Mother.
3. Peasecod Plum.
4. Damasin.
5. Holland Plum.
6. Black Damasin.
7. Black Damasin.
8. White Date.
9. Black Damasin.
10. Muscle Plum.

2nd Row there begining on ye left hand as one comes in over ye Bridge next ye Barn & hath 17 Plum trees.

1. Muscle plum.
2. White date.
3. Redd date.
4. black Damsen.
5. Winter Queen Mother.
6. Prunello.
7. Muscle.
8. Black Damasin.
9. Black Prunello.
10. Black Date.
11. Black Damasin.
12. Blater Magdalen.
13. Muscle.
14. redd Queen Mother.
15. black Damasin.
16. White peare plum.
17. Violett plum.
18. Black Damasin.

The upper end next the Great Grove & by the new Dairy 3 Trees.

2 white Damasins & redd crisky plum.

In 1681 the last notes that were entered by Sir Thomas in his 'Catley Book' had reference to preserving and candying fruit and related to the processes to be carried out by his wife.

An entry made in April gives a list of 'fruites of all sorts y[t] are fit to drye & Candy'.

1. Apricocks. 2. Nectarines, butt peaches are not convenient being very moist. 3. Plumes. 4. Cherries. 5. Peares. 6. Grapes. 7. Aples. 8. Quinces. 9. Walnuts. 10. Strawberries.

Bookes to carry for preserving & candying. 1st my wife's Manuscript in folio. 2. Rabisha of Cookery. 3. May of Cookery. 4. Contess of Kent.

Various household recipes appear to be copied from one or other of these authorities.

Sir Thomas' last garden entry is dated Jan. 27, '81. It states *Principall times for a Gardiner to bee at Catley Trees & order them*

1st in Dec. & January & Mids. to cutt trees & naile them upp.
2. in ye latter end of Feb. & March to sow Garden seed.
3. to stir ye mowles.
4. to cutt & move grasse walks & rowle the gravell walkes.

FISH PONDS

Litle Lynton ponds and ffish.

8/Oct 77 by M Turkey ffishmonger.

Carps vid: hic. page 48. What carps were putt into y' ponds here, and att Catley: there will bee by Turkey Carps and tench enough in y' great pond att Lynton and y[t] att Catley to store all y' ponds at Lynton as well as those uncast as cast, and the carps and tenches will breed well in those uncast.

Bore Hols in y' Sluce doore to lett in water and have a doore before itt to stopp the fish.

Carps in 4 years y[t] are cast in young and soe tenches will multiply in 4 years and neither of them need to have fish cast in to feed them as pyke and perch, butt are fedd with the weeds and mud of the pond alone.

Ponds cast them when the springs are lowest towards Michelms or before. 1st cast outt the water by engines or catts then cutt up the woods and roots of trees, make a hedge strong to stay the mudd, then cast out all the mud, in every part till it comes to the galt or gravell: cutt the bankes on both sids to make y' pond uniforme and equall / cast clunch at the ends of the ponds to make 2 ends and the fish will come thither and spawn or play there, and in fishing the nettes may bee drawn thither in y' nettes.

Fish are kild by Ice for want of Aire and opening the Ice or want of water in draught. Then take the fish into a pond y[t] hath

more water. Catley water in y' ponds. Cleanse ponds by cutting y' weeds with a sith and hook and taking of y' weeds and get out the sticks and wood by a great Harvest rake tyed to a rope and dragd by 2 men.

Litle Lynton ffish pondes

Paid for casting of y' great pond round the orchard. for a sluce to lett the water of y' pond into the River. [There 3 ponds within y one round, made by me 19 yr ago 1736. Cleaned vide (?) aut.]

3^d Oct 76. Rich. Stockin putt into the great pond round the orchard, small Carp from M Stewards of Haslingfield, nine score and s——185. Itt will take 200 carps and 200 tenches.

How to order y' sluce, Mills, River, Banks, weeds of y' ponds. How to secure against floods and ice. W[ha]t food or fish to give them, and when and where to bee had: and how much att a time. Gett a ffisherman to look after y' River, ponds, Swans.

July 1736. Put into ponds small jacks 21 score—24 score
(several) 24 (?) 2
from Cambr. by Ald. Nuttg— (? Nutting).

Ponds in Park put into one tench 400 from (?) Amerden, 1735.

July 1736 put into lower pond out of great 91–10 extra—
(?) eaten—

30 Mar. 75.

y^t about y new orchard by Cockli is 60 Rhoods and in some places is 3 pole over, and one w^th another is 1 pole over.

Itt may bee dreind into y river by y' sluce on a Saturday, nott to hinder y mill and by y' sluce hinder y' coming in of y' water when y' mill does stand.

Ram y Bank against y floods in 3 places. 1^st over against y Kill att y end of y pond att yy' right hand going in and 2, on y' next corner downwards on y' right hand. Cast y' ponds in Apr or May before Hay time.

Apr 75 M. Coger said y^t in Suffolk one digd y' ponds deep in y spring and lett them lye till Autumn without water or fish & in y^t time grasse grew att y bottom and sides y^t made y' carps grow great in 3 years.

Charge of casting y' great pond about y' orchard in Jun 75

for 28 pole thereof 8^s a pole	11 · 4 · 0
and for y rest 4^s 4^d a pole y^t 25 pole	5 · 8 · 4
in both.	16 · 12 · 4

They made y Hedge at their own cost v workmen y^t were to bee 30 v for their labour and I was to find them Bondes to stank with & y miller is to stop y mills 2 daies in a week.

Aug 75 Mr Cook writes from M^r Sohō y^t a few fish will store y new ponds, bec[ause] they encrease exceedingly and small fish of all sorts are properest of making stanks and particons in y great ponds where and in wt mañer.

Catley pond and ffish.

Sept 75.	The casting of itt v Bailiffs accounts	04 · 0 · 0
22 Mar 75	paid for 84 tench to stock itt (Libr. p. 300)	02 · 16 · 9
22 Mar 75	to Miller for carrying them in a cart (Libr. 2° p. 300)	00 · 8 · 0
3d Oct 76	Carps 35 putt in by Ric. Stocking yt were sent from Mr Stewards att Haslingfield [indifferent large]	00 · 35 · 0
3d Oct 76	paid to 2 men to carry them in a tubb	00 · 5 · 0
22 Mar 75	Tenches bought by Dr Hitch	
	33 from Will More att 4d	00 · 13 · 0
	34 tenches att from John Curite att 8s a piece	01 · 13 · 0
	19 tenches from Sam Yarrow att 6d	00 · 10 · 9
		2 · 16 · 9

4 Jan 76 Jos. Garrett to preserve fish in pondes in ye frost.

1st open & keep open ye mouth of ye pond. 2. Brake 1 or 2 places in ye pond round about ye compasse of a yard & take pease, straw wrapt & crowded hard together to goe a good way into ye water & reach up above ye water & frost into which the fish will come for breath & warmth and doe usually come to ye top of ye water att such a time.

3. Breake a large piece of 12 yards or more in compasse in ye pond & lay poles upon ye frost & Hole yt is broaken & some small sticks. Crosse ye poles & lay upon ye poles straw or pease straw & Horse dung to keep ye fish warme.

When ye frost & ice is melted the dead fish are upon ye topp of ye water.

Carry Carps in Basketts or Hampers 7 or 8 miles or more & lay lares of wheat straw betwixt them or flagges. By Jo. Nelson 26 Mar. 78 & carry Tenches soe.

APPENDIX B

SOME UNPUBLISHED LETTERS OF JOHN RAY

The Trinity tutor, Dr. James Duport, stated that no other pupils of his were comparable to John Ray and Isaac Barrow, the friend of Newton. The letters now printed shed light on Ray's life in Cambridge and on the doings of some of his friends during a troubled time.

The greater part of the letters of John Ray, including several not now extant, were published by the Ray Society in 1848, which in 1928 issued a second volume of *Further Correspondence of John Ray*, including all other letters then accessible. But there were known to be certain other early letters written by Ray to Peter Courthope of Danny Park in Sussex which were not available for consultation at the time, but which, by the courtesy of their owner, Sir William Campion, have now been published. Twenty-one of these letters contain matter that has not been printed in full, and six have never been published at all. Five of these supply the material quoted below.

On Sept. 26, 1660, Ray wrote from Trinity College, of which he was then a Fellow, that he had been travelling that summer with the keen naturalist, his great friend and pupil, Francis Willughby, and that during his absence the King had made Dr. Fern Master of the College, with an order to fill up vacant fellowships. Dr. Fern 'came down hither, about the beginning of August, with 14 or 15 of the old gang; who, having constituted among themselves a seniority, swore again, and then forsooth readmitted all the new Fellows, except Dr. Pratt, Mr. Disney, Scott, Davies, Senior, Long, White, Wilkes, Castle, West, Oddy; and at that time Hutchinson was also omitted, whom

since, I hear, they intend to admitt. I being then out of towne [Cambridge], and they having information that I should refuse the Common Prayer, surplice etc., they had well near passed me by; but by the mediation of some, they were content to reserve my place in case I would promise conformity. I wish they had spared themselves that trouble. . . . I have long since come to two resolutions, namely—No promise of conformity, and no orders. . . . They have brought all things here as they were in 1641: viz., services morning and evening, surplice Sundayes and holydays and their eves, organs, bowing, going bare, fasting nights.'

He then informs Courthope that one of the old Fellows, Chamberlain [Vice-Master 1666–88] has been put into his chamber, and that if he comes up he will see a new face of things. 'You must get a sarke', he adds, 'if you intend to continue any while; but I believe you will thinke it now seasonable to break off, and depart. Mr. Tracy is quite gone. Mr. Skippon hath been out of Towne a long time & I know not certainly whether he meanes to returne any more. Mr. Pockley I heare is Physitian to the garrison of Dunkerck & I have not heard of him a great while, I doubt w^t will become of him heer. I believe Mr. Willughby will have a grievous quarrell with you for not meeting him at Oxford etc. I shall conveigh yr L^r to him so soon as I can though at present I doubt where he is, whether at Middleton, Oxford or London. I had much more to write, but I hope I shall see you before I remove, which will be about the beginning of December.

Your obliged servant and orator,

Jo. Wray.

Coll. Trin: Feb: 12. 1660

Sr.

I received yours in answer to my last. I can tell you no newes of Mr. Willughby, not having heard from him since your departure myselfe. Mr. Barrow received a letter from him, but it was only to acquaint him that he had not received any letter from him or me lately; so that it seems ours directed to him miscarried. He was then at Middleton, where I suppose he still is. Mr. Senior and the rest who are

confirmed by the late Act, are opposed here by our governours: So that if they intend to come in, they must be put to sue in Westminster hall, which Mr. Senior intends not to doe, because that in case he should be reinstated, our Doctor would in a short time cast him out again for non-conformity: he being at present resolved against that. He and Mr. West have been severall times in the Hall, & so he intends to continue now & then to come in & take his Com̄ons amongst us; thereby declaring that he doth owne & insist upon his right, & if he hath a faire opportunity will effectually prosecute his businesse, I meane if it may be done without necessity of conformity.

Your cousin I hope will obtain a scholarship next election, howbeit I shall endeavour to prepare him *in utramque partem*. I suppose S^r^ you are convinced that I will doe my utmost for him, & I doe not much doubt to effect it. My businesse will be to remove all prejudice that may be upon my account. I am sure he doth eminently deserve & would not need the word or intercession of any friend, would men but doe him right. By my next you may expect something concerning plants. In ye meane time & ever I am S^r^

Your devoted Servant

Jo: Wray.

Coll. Trin. June 5. 1661.

Sir,

I was just writing to Mr. Skippon when I received yours in answer to my last of May 28^th^. I wonder how my former letter missed you; it is the first of mine that ever I remember to have fallen short or miscarried. I believe you will find it in Sussex at yr returne thither. This last week Mr. Goring of Heydon yr country-man brought his sonne hither & admitted him my pupill by advice & direction of Mr. Lynnett. No sooner was his father gone out of towne but suddainly the young G[entle]man falls sick, & I am not without suspicion yt his distemper may prove the small poxe, for which I have reason to be troubled not only in respect that disease may endanger his life, but also in fact others, & perhaps more of mine. I shall be as careful of him, & as vigilant that all good means be used for

his recovery as I can, in case his disease should prove what I feare. You wonder, it may be, at my impertinacy in telling you that I was just now writing to Mr. Skippon: all the account I can give you is because I was writing this story to him & excusing myselfe in that I had for the present thrust this Gentleman into his chamber. I perceive that you have not been idle in London, notwithstanding the unseasonableness of ye weather, & sorry I am that I should be beside such good company. I am so fixed here & determined by necessary business that I fear I shall not get loose this summer or find time enough to make such a chronicall visite. And as for my T.B. I do not find him disposed to stirre from home this year.

It's news to me that you write concerning Mr. Maplestofts intention to travell. I should be very glad to see him here, & my prayers & good wishes shall always attend him. I have no newes to tell you but only that Sir Hodshon lately died here of a violent feaver about ten dayes after that he was first taken. The Bp. of Exeter hath lately sent to me to take his son to be my pupill which I have not refused, yet still doe I retain my purpose of discontinuing, at ye prefixed terme unless I have greater obligations than those to ye contrary. So for ye present I take my leave. Your most obliged & devoted servant

Jo: Wray.

APPENDIX C

LIST OF PERSONS WHO ATTENDED LECTURES ON CHEMISTRY IN 1726–33.

A note-book describing the Chemical Lectures of Professor Mickleborough is preserved in the library of Caius College (MS. 619). It includes lists of the persons who attended between 1726 and 1733. They seem to have been charged a fee of a guinea each. To the list of names brief identifications have now been added.

The Names of the [18] Persons who went a Course of Chymistry An. Dom. 1726.

BANKS, HENRY. King's. Fellow 1723. M.P. for Corfe Castle 1741–62.

MORGAN, JOHN. Trinity. Prof. of Anatomy 1728–34.

HOUBLON, JACOB. Corpus Christi 1725. M.P. for Colchester 1735–41.

LUCAS, WILLIAM. Corpus Christi. Fellow 1724–33.

AYLMER, THOMAS. Corpus Christi. Fellow 1718–32. Vicar of St. Benet's, Cambridge.

BUTLER, JOHN. Corpus Christi. Fellow 1724.

KERRICH, SAM. Corpus Christi. Fellow 1719–29.

KENT[ISH], THOMAS. Christ's. M.B. 1726.

WILLIAMS, EDWARD. Corpus Christi. B.A. 1724–5.

MR. COCK of Corpus Christi. Unidentified; perhaps Wm. Cox, admitted 1727; M.D. 1743.

THOMPSON, PORTER. Trinity. Fellow-commoner 1725.

SANDYS, FRANCIS. M.D. 1739. Surgeon and Lecturer in Anatomy in Cambridge.

BROMLEY, HENRY of Horseheath. Clare. M.A. 1726 Created Baron Montfort.

DALE, JOHN. King's. Fellow 1726.
BARTON, JOHN. Clare. Adm. pens. 1722.
WARREN, CHARLES. Emmanuel pens. 1726.
BASKERVYLE, JOHN. St. John's. Adm. Fellow-commoner 1724.
MR. TUNHILL of Magdalene College. Unidentified.

The Names of the [23] *Persons who went thro the 2nd Course of Chymistry 1728.*

THEODORUS COLLADON GENEVENSIS.[1]
DAVID HARTLEY. Jesus. Fellow 1727–30. Practised Physic. F.R.S. 1736.
HEIGHAM, JOHN SYMONDS. Caius 1720.
PAKE, SAMUEL. Caius. Scholar 1727–32. M.B. 1732.
ODDIE, THOMAS. St. John's. Sizar 1724.
BATTIE, WILLIAM. King's. B.A. 1726–7. Practised as a physician at Cambridge. F.R.S. 1742.
TOOKE, JOHN. Emmanuel. B.A. 1727–8.
MR. HUBLON. *See last list.*
HARE, RALPH. C.C.C. Fellow 1729–40.
HECKFORD, THOMAS. Jesus pens. 1726–7. Fellow 1733.
BURTON, MICHAEL. St. John's. Fellow 1727–54.
WELBY, JOHN } Emmanuel. Adm. 1727–8. Twins, but
WELBY, WILLIAM } marked 'sen.' and 'jun.'
BANKS, ROBERT. King's. B.A. 1724–5. Prof. of Anatomy 1735–46. F.R.S. 1736.
CUTHBERT, GEORGE. Trinity. B.A. 1727–8. Prof. of Anatomy 1734–5.
PATRICK, SYMON. St. Catharine's. Fellow 1727–36.
CROFTS, JOSHUA. Trinity. Sizar 1725.
ROPER, JOHN. Apothecary.
COLLETON, JAMES EDWARD. Clare 1727. M.P. for Lostwithiel.
LUKIN, WILLIAM. Peterhouse 1726. M.B. 1733.
MORGAN, JAMES. Fellow 1725–51.
EYLES, FRANCIS. C.C.C. 1728. F.R.S. 1742.
SIR JAMES GRAY, Bart. Clare. M.A. 1729. Envoy to Naples 1753–64. One of the first excavators at Herculaneum.

[1] A John Colladon took an M.D. from King's in 1636, and, becoming Physician to the Queen, was knighted in 1664.

3rd Course began Nov. 8, 1731. [*13 names.*]

LEWIS BURWELL. Caius. Soc. com. 1729. President of Virginia.
THO. ADDAMS. Trinity pens. 1729. M.D. 1739.
JOHN LEETE. Emmanuel. Sizar 1730.
HABAKKUK LAYMAN. Caius 1726. Son of a surgeon at Diss.
DANIEL TAYLOR. Christ's 1730. M.B. 1735.
JOHN TALBOT.[1] Trinity Hall 1729.
HUMPHREY HANMER, B.A. St. Catharine's. Fellow 1730–40.
WILL. BARROWBY.[2] Emmanuel pens. 1730.
SAMUEL BRIGHAM. 'Man to Mr. Sandys.'
EDWARD HUBBARD, M.A. St. Catharine's 1718.
CHARLES TALBOT BLAYNEY.[3] St. John's pens. 1731.
WILLIAM RICHARDSON. St. John's [prev. of Jesus]. M.D. 1741.
JOHN BENWELL. Apothecary.

4th Course began Nov. 18, 1733. [*14 names.*]

CHARLES MASON, M.A. Trinity. Woodward's professor 1734–62. F.R.S. 1742.
SHEPPARD FRERE. Trinity. Fellow-commoner 1732.
WILLIAM BARROWBY. Emmanuel. M.B. (*D.N.B.*) *See last list.*
THO: POCHIN. Emmanuel pens. 1731.
PHILIP GELL. Emmanuel pens. 1732.
JOHN SUMMERS. St. John's pens. 1730. M.D. 1741.
ROBERT PACK[ER]. Emmanuel 1728.
SAMUEL BRIGHAM. Surgeon. *See last list.*
JOHN HALSTEAD. Surgeon.
RALPH VERNEY. Christ's 1733. F.R.S. 1758. (*D.N.B.*)
JOHN BENWELL. Apothecary.
[SIMON] EVERY. Christ's pens. M.B. 1740.
FRANCIS SCOBELL. Pembroke 1732.
LORD BLANEY. St. John's. *See last list.*

[1] Christian name omitted in Venn's *Alumni.*
[2] Son of W. Barrowby of St. Peter's, Oxford, Doctor.
[3] 8th Baron Monaghan.

April 24, 1741.

MR. BIDDLE. King's. Fellow 1740. M.D. 1752, practised at Richmond.

RICHARD JACKSON. Queens' 1739. 'Omniscient Jackson.'

[JAMES] COLLYER. Clare 1738.

[EDWARD] MACRO. Emmanuel 1739.

MR. HALES, a surgeon in Cambridge.

JAMES ELLIOT. Emmanuel 1739.

[RICHARD] CHASE. Emmanuel 1739. Knighted 1743.

[CHARLES] WALLOPE. Corpus Christi 1740. M.P. Whitchurch.

[JOHN] WYNNE. Corpus Christi 1740. 3rd Bart.

[DAVID] DEHANY [of Jamaica]. Queens' 1740.

APPENDIX D

THE CAMBRIDGE COLLECTIONS OF MATERIA MEDICA

Cambridge is fortunate in possessing three collections of Materia Medica which date from the early part of the eighteenth century. They are Museums in miniature—each being just such a collection as was the first collection of Hans Sloane, that formed the nucleus round which he assembled those great collections that became the British Museum. They have already been noticed on pages 330–4.

The original arrangement of the substances in the three collections was based upon that adopted by the principal authorities of the time, and has the historic sanction of Dioscorides and other early writers. The products of the three Kingdoms were kept separate. Those of the Vegetable Kingdom being divided into Seeds, Roots, Woods, Barks, Leaves, Flowers, Fruits, Gums, Resins, and Juices. The Animal products were grouped according to a zoological system beginning with Mammalian and ending with Molluscan products. The Minerals, less satisfactorily, into Metals, Minerals, Bitumens, Stones and Earths.

But owing to the collections having been used to illustrate lectures on Chemistry, and increased by additions of products from the lecturer's laboratory, the original arrangement of the inorganic specimens has been some what obscured.

The rarity of such early collections in anything approaching their original form must be our justification for printing the inventories separately, for it is only thus that the probable identity of some of the substances, which have lost their labels, may be indicated.

A report by Mr. E. Saville Peck on the Vigani Collection in Queens' College has been published by the Cambridge Antiquarian Society, vol. 34, and the 600 odd specimens in that collection are in excellent order. They correspond with the substances that the College of Physicians requested apothecaries to stock.

The early history of the collection is preserved in letters and invoices. The earliest, dated 16 January 1704, is from a London apothecary, Francis Porter. It runs:

i. 'Mr. Vigani, I sent you yesterday by Mr. Martin, Cambridge carrier, as under-written. I could not get several of the things, viz black lead Spongia, . . . fennell and Portingale jar. I was asked ten shillings for a ball that's found in a bullock's stomach.

I do not know what sort of raw sack-yarn you would have of, and no good Spanish saffron to be had, so sent none, but if you would please send me a sample of what sort of silk you would have, I will procure it for you.

I had sent these things sooner but could not get many of them. I return your bill back by the gentleman that brought it. The hazzard etc and charges would be considerable.

Your best way is to order your correspondent to send it by a safe hand, and so the party that brings it to have a receipt.

Your friend came in a-morning, and not a-drinking time. If he would have been pleased to have come back of an evening should have been glad to have presented him with a glass of wine.

I am your obliged servant,

Fran. Porter.

[*Invoice of thirty Drugs follows.*]

ii. Continuation of Invoice. The drugs were sent to Catharine Hall.

iii. Receipt for £31 14*s*., dated 8 February 1704.

iv. Receipt of Mr. Poley Clopton. [Fellow of Queens, 1695–1725; Proctor 1703–4. Founder of Clopton's Hospital at Bury. Granted M.D. Comitia Regia 1705.]

v. Letter, dated London 18 February 1703/4, made out to John Francis Vigani.

'Bought of Hen. Colchester, Druggist at the Maiden's Head

in Cheapside, in Bow Church, for the Honourable Mr. Clopton, Proctor of the Vniversity & Fellow in Queens' College in Cambridge.'

A list of substances follows, among which Oil of Cloves, Aniseed, Cinnamon, Palm Oil, Scammony, Turpentine and Spermaceti all occur in the cabinet.

vi. Continuation of no. v, enumerating

Alum roach, Aygdal Amar, Aygdal. Valencia, 4 oz. Arg. Vivum *Glass*, Bals. Peru, Bals. Capivi, Bals. Tolu, Bol. Armen, Camphor, Cantharides, Castor Fiber, Cochineal, Cassia Fistula.

vii. Invoice of goods sent by Francis Porter to Cambridge 7 March 1703.

viii. Letter from Mr. Charles Clutterbuck at ye Hour Glass in Newgate street, requesting payment for glasses from Mr. Poley Clopton.

ix. Letter dated London 12 October 1704.

'I have heard and written an account of goods sent by your order to Cambridge. I did formerly send an account of these thither which I presume by yours miscarried. I am Your obliged servant Fran. Porter.'

x. 8 August 1704. Received of Mr. Clopton £10 for a cabinet for ye use of Queens' College in Cambridge by me, John Austin.

Some of the paper 'coffins' which line the trays bear a water-mark G.R. which argues a rearrangement later than 1714, moreover the name of Professor R. Bradley appears twice. So that, when he wrote his book in 1730, he may have added some substances.

The 26 small drawers containing the collection are marked A to Z and the three larger ones are marked 1 2 and 3.

C. *Seeds*	D. *Seeds*	G. *Seeds*
1. Semen Cardamomi	1. Semen Rutae	1. Caravansa
2. ,, Saxifragiae	2. ,, Carui	2.
3. ,, Thlaspios	3. ,, Sinapis	3. Bean
4. ,, Cymini	4. ,, Lupini	4. Broad Bean
5. ,, Ebuli	5. ,, Ebuli	5. French Bean
6. ,, Psyllii	6. ,, Orange Pips [Citriae]	6. Giesi?
7. ,, Moschi		7. Indian Betel
8. ,, Anisi	7. ,, Acetosae	8–10. ?
9. ,, Santonicum	8. ,, Cardamomi min.	11. Unnamed
10. ,, Apii	9. ,, Paeoniae	12. Cedar Myrtle
11. ,, Cichorii	10. ,, Dauci Cretici	13. Peas
12. ,, Hyoscyami	11. ,, Erucae?	14. Smyric Peas
13. ,, Lactucae	12. ,, Petroselini Maced.	15. [Black Peas]
14. ,, ? nigr		16. Dwarf Peas
15. ,, Anethi	13. ,, Agni Casti	17. Rose Peas
16. ,, Carthami	14. ,, Althaeae	18, 19. ? Peas
17. ,, Cochleariae	15. ,, Melonum	20. Portugal Peas
18. ,, Nigellae Rom.	16. ,, Cucurbitae	21. ?
19. ,, Portulacae	17. ,, Cucumeris	22. Pericanthis
20. ,, Cydoniorum	18. ,, Peponum	23. Cianus
21. ,, Urticae	19. ,, Dauci com.	24, 25. Unnamed
22. ,, Alexandr?	20. ,, Amomi	26. Water Melons
23. ,, Bombacis	21. ,, Endiviae	27. ?
24. ,, Petroselini vulg.	22. ,, Ammeos	28. Unnamed
	23. ,, Plantaginis	29. ?
25. ,, Coriandri	24. ,, Saniculi dulcis	30. Lupins
26. ,, Angelicae	25. ,, Staphisagria	31. Unnamed
27. ,, Basilici	26. ,, Foenugraeci	34. Yew seed
28. ,, Milii Solis	27. ,, Papaveris alb.	36. Nasturtium
29. ,, Genistae	28. ,, Seseleos	37–46. Garden-seeds
30. ,, Foeniculi com.	29. ,, Cataputiae	
31. ,, Colocynthidos	30. ,, Nasturtii	
32. ,, Bardanae	31. ,, [Cucurbit]	
33. ,, Sumach	32. ,, ?	
34. ,, Cardui Benedicti	33. ,, Colocynthus	
	34. ,, [Empty]	
35. ,, Levistici	35. ,, [Illicium anisatum] Rhus virg.	

T. *Flowers and Fruits*

1. Flores Origani
2. Flores Stoechados
3. Flores Stoechadoes e horto Chel[sea Physic Garden]
4. Chamaemeli
5. Balaustia
6. Fl. R[osarum] R
7. Fructus Acaciae
8. Colocynth
9. Fruct. Alkekengi
10. R. Jallap, by R. Bradley
11. Rhaponticum by R. B.
12*a*. Vanillo sive Banillo
b. [Nut of *Traba natans*].

K. *Nuts*

1. Alkekengi
2. Cassia Lignea [C. Fist[ula]]
3. Nuces Cupressi
4. Unnamed.
5. Piper longum
6. Cocculi Indi
7. Chermes grana
8. Unnamed
9. Coffee
10. [Myrtilli]
11. Myrobal Citrinus
12. M. Chebulae ?
13. M. Belericae
14. M. Emblicae
15. Myrobalani
16. Anacardia occidentale antiquorum
17. ?
18. Nuces Vomicae
19. [Dates]
20. [Galls]
21. Nuces Myristicae
22. Tamarindi siliquae
23. [Cubebs]
24. Amygdala Amara
25. Grana Paradisi

N. *Barks*

1. Cortex Guaiaci
2. C. Tamarisci
3. C. Peruvianus [Cinchona]
4. C. Esulae
5. C. Capparis
6. C. Granatorum
7. C. Esulae
8. C. Citri
9. C. Winteranus
10. Empty
11. Cassia Lignea

12–15. Empty

X. *Plants*

1. Dictamnus Creticus
2. Cuscuta [Dodder]
3. Fungus Sambuci

4. 5.

6. Corallina
7. . . . Visnaga
8. Scoenanthus
9. Senna ?

10–14. Empty

P. *Roots*

1. R[adix] Sarsaparilla
2. R. Angelica
3. R. Eryngii
4. R. Turpethi
5. R. Calami Aromatici
6. Scorzonerae ?
7. Aristolochiae longae
8. R. Mei Athamantici
9. R. Costi Dulcis
10. R. Enulae Campanae
11. Unnamed
12. Alkanet

Q. *Roots*

1. Radix Aristolochiae rot.
2. R. Chinae nodosae
3. R. Curcumae
4. R. Jalapii
5. R. Iridis
6. Hermodactyli
7. R. Chinae
8. R. Bistortae
9. R. Cyperi long.
10. R. Cyperi rot.
11. R. Ellebori alb.
12. R. Tormentillae
13. R. Mechoacannae

*14. R. Behen alb.
*15. R. Behen rubr.
*16. R. Dictamni alb.

17. R. Polypodii
18. Salap
19. Rad. Traumatica ?
20. Radix Acori Pharmacopolis Galangae majoris officin.

S. *Woods*

1. Lignum Lentiscinum
2. ,, Aspalathum

2a. ,, Nephriticum

3. ,, Colubrinum
4. ,, Juniperi
5. ,, Santalum album
6. ,, Rhodii
7. ,, Aloes
8. ,, Santalum citrinum
9. L. Guaiaci. [*Lignum Vitae Guaiacum officinale*]
10. Viscus Quercinus. [Mistletoe Oak]
11. L. Santalum rubrum. [Red Sanders, *Pterocarpus santalinus*]

Z. *Roots, etc.*

1. Tacamahaca [Resin in shell of Gourd]
2. Radix Contrayervae
3. R. Phu. [Spikenard of Bitu
4. Radix Ellebori nigri
5. Radix Azari
6. Zedoaria
7. Rubia Tinctorum
8. Cassaminaris
9. Radix Pyrethri
10. ,, Gentianae
11. ,, Galangae minoris
12. ,, Rhabarbari
13. Ipecacuannha [Carthagena]
14. Rad. Rhapontici
15. Rad. Filipendulae
16. R. Serpent[ariae] Virginianae
17. Balsamum Tolutanum [in gourd shell]

A. *Gums*

1. G[ummi] Sarcocolla
2. Gum Senica
3. Labdanum
4. Labdanum verum antiquorum
5. Gum Animi
6. Euphorbium
7. Gum Lacca in granis
8. Gum Lacca in massa
9. Gum Carannae
10. Gum Hedera
11. Mastiche
12. Styrax Calamita
13. Olibanum
14. Gambogium
15. Opopanax
16. Arabicum
17. Benzoin
18. Sagapenum
19. Styrax non Calamita
20. Scammonium
21. Gum Copal
22. Tacamahaca
23. Pix Burgundica
24. Gum Elemi
25. Gum Guaiaci
26. Sandaracha
27. Galbanum
28. Bdellium
29. Ammoniacum
30. Gum Tragacanth

H. *Juices*

1. Manna
2. Manna in granis
3. Succus Acaciae
4. Succus Hypocistidos
5. Terra Japonica
6. Myrrha
7. Succus Glycerize
8. Aloes rosat
9. Aloes Caball[ina]
10. Aloes Hepat
11. Sanguis Draconis as it drops from ye Tree
12. Sanguis Draconis in calamis brevioribus
13. Sanguis Draconis in calamis longioribus
14. Unnamed [? Pitch]
15. do.
16. do.
17. Opium
18. Heliotropium . . . cendens
19. Unnamed (? do.)
20. do.

(1) *Oils and Balsams*

1. Bals. Peruv. 28
2. H. P. ?
3. Storax Collat. 28
4. Succus Koimis. 28
5. Ol. Laur. 28
6. Bals. Capivi. 28
7. Ol. Palmetiae
8. Ol. Palmae
9. Assafoetida
10. Terebinthe Chio.
11. Terebinth Strasb[urgh]
12. ?
13. Venice Turpentine
14. Trageum
15. Unnamed
16. Venice Turpentine
17. Bals. Gillead

(2) *Oils and Balsams*

1. Bals. Peru[vianum]
2. ,, Capivie
3. ,, Amerie
4. ,, Gilead
5. Ol. Petraelaeum album
6. Ol. Petraelaeum nigrum
7. Ol. Anisi
8. Ol. Terebinth
9. ?
10. Ol. Caryophyl
11. Ol. Anisi
12. ?
13. ?
36. Sulphur Antimon

R. *Animals*

1. Cap[reolus] Moschi
2. Castoreum
3. Ovarium . . . vivipara
4. Vipera
5. Ichthyocolla
6. Chelae Canc[rorum]
7. Ossa de Corde Cervi
8. Scorpio
9. Sanguis Hirci
10. Spermaceti
11. Oculi Cancrorum
12. Cochinella
13. Sericum crudum
14. Cornu Cervi Rasp.
15. Hippocampus Rondeletii
16. Civet [in a vessel of green glass]
17. [Cantharides]
18. Scinci Marini

O. *Shells*

1. Conchites Echinites clavicularis 988
2. Concha fasciata Jonst.
3. Concha longa, Rondelet
4. Cochlea cylindroides
5. Trochus pyramidalis depressus
6. Trochus pyramidalis
7. [Coneshells]
8. Pecten
9.
10. Turbo variegatus
11. Turbinites minimus fusillatus N. 363
12. Turbines [Whelk from Crag]
13. Cochlea depressa, una cum albo Nautilo [Planorbis]
14. Nautilites complanitior N. 270 [Ammonites from Lias]
15.
16. Murex marmoreus
17. Purpura
18. Nerita

W. *Fossils*

1. Mater Margaritarum [*Haliotis*]
2. Concha Veneris [*Cypraea moneta* Paper '1698']
3. Conchites
4. [Echinoid]
5. [Echinoids]
6. [Echinoids]
7. [Iron Pyrites, Marcasite]
8. [Fossil Oyster]
9. Ammonite Calcite or a Nautiloid [Cornu Ammonis]
10. Echinoids
11. Backbone of Ichthyosaurus Lapis spinalis
13. Tophus Bovinus [Coral]
14. [Horse's Tooth]

L. *Fossils*

1. [Calcareous incrustation]
2. Entrochus compressus gemellatus N. 114
3. Entrochi from Torpenhow in Cumberland
4. Entrochus from Cumberland lodg'd in an Iron Earth
5. Entrochus cylindraceus sive complanatior max(?) N. 1133
6. Cuen . . . gosa [a ribbed bivalve] N. 713]
7. Terebratulae capsularis N. 866 non diffin
8. Echin
9. Muscus petrif [? Travertine]
10. . . . of Scotland
11. [Echinid spines]
12. Ostrea minus falcata N. 451
13. Terebratula vulgata ovalis N. 837
14. Gryphaea 487
15. Gryphaea ? 483 (or 433)
16. [Incrustation from spring]
17. No specimen
18. [Iron incrustation]
19. Mytiloides vulgatior Anglicus N. 884

20*a*. [Serpula tubes]

20*b*. Lapis e Rene ovis

21. Pectunculites Oxyrhynchus N. 664 [Rhynchonella sp.]
22. Lapides Plantae marinae tenui filo nexae
23. Lapis e Vesica Bov.
24. Lapis e Vesica Lupi
25. Lapis e Vesica pueri per —Atherton, M.D.

F. *Stones*

1. Lapis Haematities
2. Lap. Amethystus
3. Bezoar orientalis
4. Bezoar oriental
5. Lap. Topasius
6. Lap. de Goa
7. Lap. Smaragdus
8. Lap. Granatus
9. Lap. Chrystallus
10. Lap. Rubinus
11. Lap. Lazuli alia
12. Lap. Hyacinthus
13. Lap. Gagati [Jet]
14. Lap. Nephriticus
15. Lap. Nephrit. alia
16. Lap. Nephrit. laevigat
17. Margaritae Orient.
18. Lap. Armenius, sive Lazuli alia
19. Margaritae Scot.
20. Lap. Saphirus
21. Lap. Judaicus
22. Margaritae Orient
23. Lap. Contrayerva
24. Lap. Magnetis
25. Lap. Lyncis
26. Margaritae Occid.
27. Globuli Arenae grandiores
28. Selenites
29. Sharks' Teeth [Fish Otoliths]
30. Magnes [Lodestone]

E. *Minerals*

1. Vitriolum album
2. ,, viride
3. ,, romanum
4. [Empty]
5. ,,
6. Arsenicum rubrum
7. Alum Roch.
8. Amiantus [Asbestos]
9. Talcum commune
10. ,, Venetum
11. ?
12. Arsenicum album
13. Succinum citrinum
14. Succinum flavum
15. Succinum album
16. Succinum nigrum
17. Ambreigrisea
18. Arsenicum citrinum
19. Praecipitatus
20. Sulphur cru.
21. Sulphur nativum Persicum
22. Sulphur nativum Lancastriense
23. Minium
24. Cerussa
25. Cinnabaris nativa Persica
26. Cinnabaris nativa e Guinea
27. Cinnabaris nativa Hungaricus
28. Cinnabaris nativa alia species
29. do.
30. Cinnabaris factitia

M. *Earths, etc.*

1. Lapis Aetites
2. ,, Calaminaris
3. ,, Tutiae
4. ,, Hiberniae
5. ,, Hiberniae figura Filicis notatus
6. ?
7. Bologn. Tartar
8. Tartari Cremor J. Francis Vigani
9. Bolus Armenia
10. Tartar Alba
11. Terra Sigill. rubr.
12. ,, alb.
13. ,, Lemnia
14. Lapis Spongosa
15. Osteocolla
16. Corallium Rubr.
17. Corallium fistulatum
18. Sal nitrum non defoecat
19. Sal Nit. defoecat
20. Corallium alb. [Calcareous alga]
21. Corallium alb. Fist. opt.
22. [Madrepore Coral]

U. *Minerals*

1. Minera Antimonii alia
2. Antimonium ex Hungaria
3. Antimonium ex agris Cornub. in Anglia
4. Regulus Antimonii ex Antim. Anglicano
5. Stibium ex Antimonio Hungarico
6. Minera Bismuthi
7. Bismuth
8. Lithargyrus argenteus ex officinis Novi-Castri, in Anglia
9. Aureus ex iisdem officinis
10. Despumatio Plumbi, ex iisdem officinis
11. Fuligo ex iisdem officinis, an Antiquorum Pompholyx
12. Minera Cupri Anglicana in qua reperitur Lapis Lazuli

U. *Minerals* (*continued*)

13. Cuprum ex agris Lancastr. in Anglia
14. Cuprum Americanum
15. Minera Auri Hungarici
16. Spelter
17. Bristol Stone
18. Found in great balls among Fullers Earth near Rygate in Surrey [Baryta]
19. Lapis Specularis [Talc]
20. Unnamed

I. *Pigments*

1. Deep Smalt
2. Suptsune ? of Smalt
3. Blew Fol.?
4. Calcin'd Smalt
5. Blew Verdit
6. Blew Bice
7. Ultramarine
8. Spanish Wool
9. Carmine
10. Vermilion
11. Red Lead
12. Indian Red
13. Spanish Red
14. Roman Oker
15. Bole Armen.
16. Fine Russet
17. Unnamed [Vitr. Romanum, $CuSO_4$]
18. Green Pr.
19. Verdigr. Fine
20. Terre Vert
21. Verditure
22. Gold Bronze
23. Water Gold
24. Japonnicum Ab.
25. Deepest Orange
26. Deep Orange Sp.
27. Red Orpiment
28. Masticote Deep
29. Dutch Pink
30. Yellow Masticot
31. Orpiment
32. Pale Masticote
33. Light Orange Sp.
34. Gold Fr.
35. French Oker
36. Gold Colour'd Sp.
37. Dutch Gold
38. Silver Colour'd Sp.
39. White Sp.
40. Cerusse
41. Ivory Black
42. Jamaica Indigo
43. Sap Green
44. Colens Earth, Terra Lemn.
45. Burnt Umber
46. Umber
47. Unnamed
48. Lem . . .
49. Unnamed
50. ,,
51. ,,
52. Lake
53. Unnamed
54. Copper col. Spec.
55. Rose Pink, Red Oker
56. Venice Lake
57. Unnamed
58. ,,
59. Brown Fr.
60. Ash Colour Fr.
61. Unnamed
62. ,,
63. Indicum Atramen [Indian Ink]

Pigments in boxes (c)

1. Fine Black
2. Fullers Earth
3. Boll-Armenick
4. Burnt Amber
5. Jamaica Endico
6. Salop
7. Deep Stronn Smalt
8. Rose Pink
9. ?
10. Ivory Black
11. Sapph. Green
12. Flat Oaker
13. Roman Oaker
14. Fine Roset
15. French Oaker
16. Crimson Culler Speckets
17. Blue Black
18. Super-fine cal-sind Smalt
19. Venice Vipers

NO. 252. THE VIGANI CABINET OF MATERIA MEDICA

Queens' College

Y. *Preparations*

1. Tamarinds
2. Sugar of Lead
3. Pulv. e Chel. Cancr. Comp. R. ʒii
4. Antihecticum
5. Balsam Lucatelli
6. Pil. Stom. et Gum. R. ʒii
7. Spec. Aromat Rosat. ʒii
8. Pulv. Rad. Ari. Comp. R. ʒii
9. Pulv. Comitis Warvicensis R. ʒii
10. Emplast. Paracels Compa. ʒii
11. ?
12. Elect Caryocostin. ʒii
13. ?
14. El. de Baccis Laurd ʒii
15. Laud[anum] Londin[ensis] R. ʒi
16. ?
17. ?
18. Extract Rudii. R. ʒii
19. Emplastr. Oxycroc ʒii
21. Unguent. Basilicon. ʒii
22. Unguent. Gum Elemi ʒii
23. Unguent. Egyptiacum ʒii
24. Powdered Myrrh of Carlisle
25. Pil. Coch. Major. R. ʒii
26. Pil. E. Styrace. R. ʒii
27. Pil. Starkaci
28. Emplast. Adhesis. R. ʒii
29. Emplast. Paracels. ʒii
30. Emplast. Diachyl. Simp. ʒii
31. Cons. Alherm. S.M. ʒss
32. ?
33. Empl. e Mucilag. R. ʒii
34. Troch. de Carabe
35. ,, de Myrhee
36. ,, Alhandal
37. ,,
38. Fledychr.
41. Unguent Apostolor. ʒii

Lower Drawers

(a) *Packets, Containers, &c.*

Arrowroot
Shellac
Gum Tragacanth. Exceeding Fine
Bark of Sasafras
White Lead
Oyster Shell
Alum
Purified Zinc
Seed Lac and Shellac
GypsumPonderosum
Manackanite from Mr. Milner Quarry for Dr. Pearce. [It is wrapped in a newspaper dated 1790]
Spermacete
Soap Cerate
Manganese
Wootz.[1] [Apparently a part of an ingot of steel received by Dr. Heberden from Sir Joseph Banks. It is mentioned in a letter addressed to the Dean of Carlisle.]
Lapis Calaminaris

(b) *Packets, &c.*

Saltpetre
Arsenic
Assafoetida (finest)

(c) *Boxes of Pigments*, see p. 480.

[1] Wootz steel is made in Southern India by fusing in a crucible magnetic iron ore with carbon. This sample is older than the first literary reference, *Phil. Trans.* 1795.

A CATALOGUE OF THE SPECIMENS OF THE HEBERDEN COLLECTION OF MATERIA MEDICA IN THE CABINET IN ST. JOHN'S COLLEGE LIBRARY

The Heberden Collection, rather later in date than the other two, is decidedly the larger and the one most nearly in its early state, as shown by an early manuscript catalogue of July 10th, 1751. Dated Additions were made in 1742–4.

Seeds

Drawer 1

Semen Sinapeos
Pimpinellae Saxifragae
Cari
Nigellae
Staphidos Agriae
Levistici
Acetosae
Anisi
Foeniculi vulgaris
Cymini
Agni Casti
Erucae
Sophiae Chirurgorum
Ptarmicae
Hipposelini
Ammeos
Amomi officinarum veri
Apii
Dauci Cretici
Seseleos
Foeniculi dulcis
Bamiae Moschatae
Anethi
Angelicae
Coriandri
Cardamomi minoris
,, majoris
Grana Paradisi

Drawer 2

Semen Nasturtii sive Thlaspios officinarum
Cydoniorum
Ciceris
Papaveris albi
,, nigri
Psyllii
Aquilegiae
Peponum
Foenu-graeci
Melonum
Cucumeris
Cucurbitae
Hordeum perlatum
,, Mundatum sive [Gallicum
Sesami
Citrulli
Cichorii hortensis
Portulacae
Lactucae
Endiviae
Lupini
Hormini sylvestris
Santonici
Sumach
Mespilli
Milii [Solis]
Panici
Lini

Drawer 3

Semen Cardui Benedicti
Genistae
Petroselini Macedonici
,, vulgaris

Semen Citriae
Paeoniae
Napi dulcis
Urticae Romanae

Drawer 3 (*continued*)

Semen Atriplicis Olidae
Lolii
Cepae
Cannabis
Basilici
Colocynthidos
Carthami
Dauci sylvestris
Pastinacae sylvestris
Canotius Spondylii
Bardanae
Urticae
Hyoscyami albi
Lentis
Althaeae
Vermiculi
Zeae sive Speltae
Cataputiae
Lithospermi
Violae

Drawer 4

Semen Caryophylli Indici
Fructus Caffae
Cubebae
Nux Moschata Condita
Saxifragae albae
Rapi
Lolii
Bombacis
Sesami
Raphani hortensis
Lapathi acuti
Cardui Mariae
Digitalis
Myrrhidis (missing)
Iberidis
Hyperici
Orobi
Rutae sylv. (missing)
Loti
Fructus Baniliae
Cassia Fistula

Flowers, Nuts, and Fruits

Drawer 5

Succus Acaciae
Myrh Baccae
Fructus Cacao
Nucleus fructus Arecae
Carpobalsamum
Euphorbium
Piper Indicum
Succus Hypocystidis
Gallae
Cortex Citriorum
Cortex Granati
Nux Cupressi
Piper Iamaicense
,, Nigrum
,, Album
Baccae Lauri
,, Juniperi
Piper longum

Drawer 6

Jujubae
Dactyli
Nux Vomica
Siliqua hirsuta
Cocculus Indus
Anacardium orientale
,, occidentale
Fructus Sebesten
Faecula Bryoniae
Elaterium (vid. No. 13)
Nux de Ben
Fructus Alkekengi
Myrobalanus Chebulus
,, Citrinus
,, Bellericus
,, Emblicus
,, Indus
Siliqua Tamarindi

Drawer 8

Flores Stoechados Balaustii
Folliculi Senae
Fructus Tamarindi
Fructus Colocynthidos

Anthos [Rosmarinus]
Flores Origani Cretici
Stamina Croci
Usnea Cranii Humani

The collection of Roots is most complete, no less than 65 being listed.

Drawer 7 Roots

Radix Valerianae sylvestris
Nardi Celticae
,, Indicae
Zedoariae
Zinziberis
Zinziberis nigri
Anthorae (*missing*)
Cyperi rotundae
,, longae
Ginseng ex America
Doronici
Galangae
Ginseng e China
,, e Carolina
Acori veri
Angelicae Hispanae
Cassummuniar
Caryophyllatae
Contrayervae

Drawer 9 Roots

Radix Rubiae Tinctorum*
Costi dulcis
Pyrethri
Tormentillae
Solani Lethalis
†Gentianae verae
Anchusae
Enulae Campanae
Bistortae
Serpentariae Virg.
Curcumae
Petasitidis
Aristolochiae Clematitidis
Aristolochiae longae
,, rotundae
Mei Athamantici
Fraxinellae

* 'Ossa Gallorum Gallinaceorum rubro colore tincta, qui per xii dies farina Hordei partibus ij, radice Rubiae Tinctorum parte una vescebantur. (In Drawer 11.)

† 'The darker color'd Poisonous Root lately found among the Gentian of which a woman was poison'd; an Rad. Hyoscyami.' See Miller's Plants.

Drawer 10

Radix Hermodactyli
Rhabarbari Veri
Ialapii
Turpethi
Thapsiae
Esulae
Hellebori Albi
,, Nigri
Mechoacannae
Polypodii
Althaeae
Salep
Scorzonerae
Eryngii
Alni Nigrae
Pilulae No V. cx. Ialapii ji, Mucilag G. Tragacanthae q. s. confectae

Drawer 11

Radix Cynoglossi
Traumatica
Valerianae hortensis
,, Sylvestris hyeme effossa
Senegae
Pareirae Bravae
Iridis Florentinae
Chinae
Chinae Nodosae
Sarsaeparillae
Rhapontici
Rharbarbarii Monachorum
Azari
Ipecacoanhae
Filipendulae

Woods

Drawer 12

Lignum Tinctorium
,, Nephriticum
Gummi Campechense [G. of Logwood]
Lignum Guaiaci
Sassafras
Amygdalae Amarae
Aloes
Mancanilla
Juniperi
Rhodium
Cupressi
Tamarisci
Colubrinum (*missing*)

Drawer 26

Gummi Benzoinum
Resinae ℥iiss ex Corticis Eleutheriae
Zei
Extractum Corticis Peruviani Epithymum
L. Santalum Citrinum
,, Rubrum
A Hair-Ball
Lignum Lentiscinum
Alum from Solfatara
Calcind matter from Vesuvius
Resina é Styrace Calamita officinarum ope Spiritus Vinosi elicita. March 1744
Ebenus
Gummi Guaiaci
Lignum Camphorae
Cortex Brasiliensis
Cornu Cervi calcinatum

Drawer 14

Cannal Coal
Pieces of Coco shell
Sugar Cane
Juncus Odoratus sive Schoenantus

Barks

Drawer 21

Folium Indum sive Malabathrum
Lignum Agallochum given by P. Burrel Esq., whose relation brt it as a great variety from China, where it is used as incense
Cortex Cassiae Caryophyllatae
,, Sassafras
,, Guaiaci
,, Tamarisci
,, Peruvianus
Corticis Peruviani Jir in chartulis
Cortex Capparis
,, Winteranus
,, Eleutheriae
Pilulae ex Corticis Peruviani
Cortex Cinnamoni
Capiae ligneae optimum specimen

Drawer 25

Corallium
Manna
Semen Arboris Peruviani
Muscus Pyxidatus
Gummi Hoc
Polium Montanum
Flores Chamaemeli
Agaricus
Folia Senae
Lichen cinereus terrestris
Auricula Indae
Dictamnus Creticus
Corallina
Corallium rubrum
,, album

G. Benzoin, foliis amictum
Asbestos
Aluminis Minera. Ore from Whitby 1742

Drawer 19

Terra Japonica
Sanguis Draconis
Sanguis Draconis
Opopanax
Sagapenum in Pyxide
Gummi Anime
  ,, Anime falsum
  ,, Labdanum in Pyxide
Aloe Socotrina
  ,, Caballina
Bdellium
Galbanum
Asa Foetida in Pyxide
Arabicum
Cerasorum
Senega
Tragacantha
Sarcocolla
Ammoniacum

Drawer 20

Styrax Calamita
Gummi Mastiche
  Labdanum
  Siliqua dulcis
  Juniperi
  Olibanum
  Caranna
  Lacca in ramulis
    ,, granis
    ,, massa
  Hederae
  Another specimen from an old tree near the Abbey of Bury St. Edmund's.
Gummi Hederae spiritu vini paratum
  Myrrha
  Elemi
  Copal
  Camphora
  Tacamahacca
  Thus Vulgare
  Benzoinum
  Balsamum Tolutanum

Drawer 18

Opium
Opii gr ii=gr iii
Pilula é Styrace
Opii JV—1 Scrupulus
  ʒi—1 Drachma
Sulphur ex Vesuvio. Quo jure vocatus 🜍 nescio, nam neque olit 🜍, neque igne inflammatur aut liquefit. Expertus sum Feb. 10. 1742/3
Scammonium
Gambogia
Sal Catharticus Glauberi
Resina Ialapii
Antimonii Crocus
Antimonii Vitrum

Drawer 18

Auripigmentum rubrum sive Sandaracha
French Chalk
Vitriolic substance made at Solfatara
Sal Ammoniacus
Resina Scammonii
  ,, Jalapii
Opii granum unum
Resina corticis Peruviani
Resinae ex vilis corticis Peruviani ʒiv.
Resina Guaiaci
Crystalli Tartari
Tartarum crudum

Substances in stoppered bottles

Drawer 13

Balsamum de Copaiba
Tinctura Corticis Peruviani
 Spiritu Vini parata
Flores Bismuthi
Balsamum Gileadense verum
 Officinarum
Nitron sive Natrum Aegypti
Camphora cruda
Oleum Terrae album
Petraelaeum nigrum
Liquidambar
Balsamum Peruvianum
Phosphorus liquidus
Substantia calcaria ex aqua
 Collegii S. Trinitatis

Pix Barbadensis
Oleum Petrolei veri
Oleum Sinapeos expressum
Mercurius Vitae
Oleum Caryophyllorum
Tinctura Corticis Peruviani cum
 Spiritu Salis Ammoniaci
Scorpius
Oleum Cerce
Balsamum Polychrestum
Sal Succini
Oleum Succini
Oleum Cari chemicum
Elaterium
Camphora

Substantia quaedam ex muro balnei calidi 'scrap'd off the wall
 of a Hot Bath. H.' In Drawer No. 11
Tartarus solutione et filtratione purificatus. (In No. 11.)

12 (*half*)
Substantiae [moss, twigs, &c.], quaedam petrefactae ex Knaresboro
Bitumen Nativum Pitchfordense
Oleum Palmae
Styrax liquida et colata

Terebinthina Chia
 ,, Veneta
 ,, Communis

Animal Products

Drawer 23
Sperma Ceti
Idem in pyxide
Glossopetrae
Os Carpionis
Icthyocolla
Margaritae Orientales
 ,, Scoticae
Seed Pearl
Oculi Cancrorum [June 1769
Lapillus Cancri verus, May and
Mater Perlarum [narum
Asselli os sive Dentalium offici-
Grana Kermes
Os Sepiae
Cantharides
Coccinella
Folliculi Bombycum

Drawer 24
Mumia
Calculus é Vesica humana
Castoreum é Nova Anglia
Castoreum Russicum
Mosschus
Zibethum [in green glass vessel]
Os é Corde Cervi
Bezoar Occidentale
Ungula Alcis
Bezoar Orientale
Chelae Cancrorum (*missing*)
Rasurae Cornus Cervi
Dens Apri
Sanguis Hirci
Lapis ex Felle Bovis
Scincus

Drawer 14

Hippopotami Dens
Crystalli Salis Ammoniaci
Gummi Anime falsum

Cervi Priapus
Muscus Indus

Mineral Products

Drawer 15

Sulphur ex Aquisgrano
Terra Ampelytes
Bitumen Indicum
Gagates
Succinum citrinum
,, album
Tripolis

Sulphur nativum
Auripigmentum
Auripigmenti flores citrin
Arsenicum citrinum
,, album
,, rubrum
Ambargriseum

Terra Lemnia
,, Samia
Bolus Bohemica
,, Armena
,, Blesensis sive Gallica
Terra Silesiaca
Rubrica Fabrilis
Ochra

Drawer 16

Alumen Plumosum
Talcum Venetum
,, commune
Asbestos [= Amiantus]
Lapis Lazuli
,, Armenus
,, Hibernicus

Lapis Calaminaris
Osteocolla
Pumex
Lapis Spongiae
Vitriolum Album
,, Viride
,, Caeruleum
Borax sive Fincar

Sal Catharticus Amarus
Sal Prunellae
Sal Ammoniacus ex Solfatara
Alumen Rupeum
Nitrum
Nitrum Purificatum

Drawer 17

Lapis de Goa [a gilt hemisphere 1 inch diam.]
Philosopher's Stone
Adamas
Lapis Turchois
,, Topasium
,, Sapphirus
,, Amethystus

Lapis Smaragdus
,, Indarius
,, Hyacinthus
,, Acqua Marina
,, Granatus
,, Rubinus
,, Heliotropium
Carneolus
Achates Mochoensis

Asteria
Cornu Ammonis
Belemnites
Lapis Nephriticus
,, Aetites
Crystallus Islandica
Crystallus
Lapis Selenites
,, Specularis

Drawer 22

Mercurius alcalizatus
Aethiops Mineralis
Pyrites
Mundick
Stannum
Pompholyx
A substance whose weight is to water :: 9, 3, 1, with which Gold is said to be adulterated.
Aes Viride
Mercurius extinctus Balsamo Sulphuris Terebinthinato
Cinnabaris Nativa bis
Tutia

Minium
Bismuthum
Cerrissa
Lapis Haematites
,, Smyris sive Smerillus
Chalybs en Aceto Sulphure paratus
Lithargyrus
Antimonium
Cobaltum verum ex fodina Rappolt juxta pagum Sneeberg Saxoniae superioris
Magnes

A substance found plentifully near the stinking well at Harrogate.

Drawer 27. Substances in stoppered bottles

Magisterium Bismuthi
Tartarum solubile
Benzoarticum Minerale
Tartarus Emeticus
Mercurius Praecipitatus viridis
Sulphur Antimonii B. Proc 209
Oleum Rosarum
Mercurius Praecipitatus albus
Colcothar Vitrioli
Saccharum Saturni
Cinnabaris Antimonii
Sal Jovis
Mercurius Emeticus flavus
Sulphur Praecipitatum Antimonii
Causticum Antimoniale
Flores Sulphuris
Balsamum Sulphuris Terebinthinatum
Aurum Musivum
Mercurius calcinatus
Flores Salis Ammoniaci Martialis
Calx Antimonii
Causticum Lunare
Mercurius Corrosivus ruber
Hepar Sulphuris
Antihecticum Poterii
Spiritus Cornu Cervi
Ens Veneris
Balsamum Terebinthinae
Sal Martis
Spiritus Viperarum
Cerussa Antimonii
Mercurius Sublimatus dulcis
Calomelas
Cinnabaris Factitia
Flores Salis Ammoniaci
Oleum Animale
Tartarum Vitriolatum
Oleum Terebinthinae
Mercurius Sublimatus Corrosivus
Oleum Sassafras chemicum
Flores Benzoini
Lapis Septicus

Drawer 28

Residuum Cinnamoni post distillaticum
Species pro Tinctura Helvetii, bis
Sulphur
Smyris
Red Rag
Limatura Ferri
Folia Senae Feb. 22 1743/4
Soap Stones
Lacca in Granis

Drawer 28

Limatura Oris
Squat Root
Alum
A little box of Fossils
A piece of Marcasite
Bristol Stones—gathered at Lessington
Cornu Ammonis
Pumex
White Arsenic

In the lower part of the Cabinet

Radix Alni nigrae

The Pape collection of dried plants

With a manuscript list of 'Numbers and Names of [leaves of] 671 Plants in the Book. By Thomas Pape, Teacher of Navigation in Scarborough, Yorkshire'.

There are also twenty specimens of leaves of medicinal plants including Tea, Cinnamomum verum, Piper nigra, Corallium flavum [*Flustra*], &c.

THE ADDENBROOKE COLLECTION IN ST. CATHARINE'S COLLEGE

The Addenbrooke Collection is in less satisfactory order. The contents of most of the drawers have been seriously disarranged. Wrappers and labels have got lost or mixed. The items that remain in situ suggest that the original arrangement was alphabetical, and this perhaps would now be the most convenient method for restoring the scattered collection to order.

A part of the collection can claim the merit of superior antiquity, for it is associated with James Symonds whose contributions go back at least to the year 1662. Special features are the drawers of fossils presumably from the Chalk of Cherryhinton, and a few ethnographical specimens comprising a wooden sabot, two beads of jet, two Neolithic celts, one of highly polished Greenstone Jadeite, a barbed spear-head, the skin of a Globe fish, and most interesting of all a comfortably curved and smoothed Nephritic Stone of dark-green serpentine, perforated at each end, and measuring 8 inches by 3½ inches.[1] Figure

[1] 'The *Nephritick Stone* is a greyish stone, with a little mixture of Blue in it, so that it is usually of a bluish-grey colour, being fat and oily like Venetian Talck. This Stone is much valued by certain persons for the cure of the Gravel, which makes it so scarce and so much enquired after, because of its virtues which it performs by hanging about the Thigh of those who are troubled with the Stone or Gravel in the kidnies, from whence it is call'd the *Nephritick Stone*.

'The dearness and rarity of this stone is the reason why some have substituted in its stead a kind of green marble surnam'd *Malaquitte*, and cut and carve it like a Bird's head, because the ancients believ'd that the true *Nephritick Stone* resembled a Bird's head, or the beak of a Perroquet. The true *Nephritick Stone* comes from *New Spain*; and whoever would know further of it may read

NO. 253. ADDENBROOKE CABINET OF MATERIA MEDICA
1690–1700
St. Catharine's College

on p. 494. Also a document that may suggest the origin of these relics:

'China paper thinne and strong made of silke, given mee Nov. 13, 1662 by Mr. James Symonds', whose name is associated with the Nocturnal described on p. 188.

This early date is confirmed by another label 'A stone. A bone taken out of a Carp fish-head 1664'; and, better, by the paper in which the Moss from a human skull was wrapped, which was part of 'Mr. John Pike, his accompt' of dated items

1645 July 30	A bath
	A plaister
Aug. 1	A bath
	A plaister
4	A purge

A large number of the substances, now mixed and having lost their labels, can doubtless be rearranged and named. The following inventory is confined to names written on old labels. Names in brackets are of other substances which I have identified.

Nuts, Seeds, and Fruits

Drawer 1

[Anacardia]
Cassia fistula
Coffee
Colocynth
Grana chermes
Grana paradisi
Granadillae peruvianae
[Juniper]
Nux vomica
[Passion flower]
Piper long
,, de Ginea
[Sem. Ricini]

Mr. Worms, who has write a large description of it, too long to be inserted here.

. . . 'For the most part they are found like whet-stones in the fields in great lumps, so big that a cup may be made of them. *Carolina* affords pretty large ones, of about eight inches long, three broad, and two thick, of an ash-colour'd green. They are likewise gather'd in *Bohemia* and several parts of *Spain*, but those are not so much esteem'd as what comes from *America*.

'This stone has the property to ease the Stone Colick, to break the Stone in the Reins and expell Gravel by Urine, being hung about the neck, thigh or arm.'

Pomet, *A Compleat History of Druggs*. London 1712.

Seeds

Drawer 5

Semen Agni Casti
Ameos
Anethum graveolens
Anisi
Angelicae
Amomi
Apii
Aquilegiae
Balostia
Bardanae
Cardamom
Cardui
Carthami
Carui
[Cochlearia]
Cichori
[Colocynth]
[Coriandrum sativum]
[Cubebs]
Cucurbita
Cuscuta
[Date-stones]
Endiviae
Foeniculi dulcis
Foenum graecum
Genistae
Jusquimiani
Lactuca
Lini
Mellonum
Millii Solis
[Momordica]
Nigellae Romanae
Paeonia
Petroselina
[Plantago Psyllium]
Punicogranatum
Sanctonica
Sticas Arabicum

Roots

Drawers 3 *and* 7

Radix Angelica
Aseri (3) and (7)
Arist[olochia] longa
Arist. rotunda (12)
Brioniae
[Belladonnae ?]
Bistortae
Radix Bracken
Canna . . .
Cassia . . . manna
[Calumba]
China
Cipri
Curcuma
Eringi
Galanga major
Gentian
Heleb. alb.
Heleb. nigr.
R. Iridis Florent.
Jalapium
Rad. Rubiae Tinctorum
Polipodium
Rad. Pyrethri
Salop
Sassafras
? [Sambul]
Serpentina virg.
Tormentillae
R. Turpethi
Valeriana graeca
Zedoaria
Zingiber

Barks and Woods

Cortex radicis caparum
[Cinchona]
Cortex Guiaci
Cortex Granat. fructus
Lignum Aloes
Lignum Brazil
Lignum Buxi
Lignum Cypri
Lignum Nephriticum (13)
[Ebony] (7)
[Yellow bark] (4)
Snakewood (13)

Gums and Juices

Drawer 2

Gum Amoniacum
Arabicum
Asafoetida
– – –
Benzoin
Caranna
Sanguis Draconis
– – –
[Cassia]
Tragacanth
Sanguis Draconis
Aloe Hepatica
Thus
Aloe Succotrina
Aloe Hepatica
Scammonium

Drawer 2. Gums and Juices (continued)

Elemi
Euphorbia
Galbanum
Gambodium seu Gutta Gamb.
Guiaci
– – –
– – –
– – –
– – –
– – –
Lacca
Lacca
Lacca [Civet]
Mastiche
Myrrh
Mastick
Opium
Opopanax (4)
Pix Burgund.
Sagapenum
– – –
Sarcocolla
Senica
Styrax

Bals Tolutanum
Colophonia
Galbanum colatum
– – –
[Catechu]
– – –
Oleum Maci
– – –
[Colophonium resin]
[Burgundy Pitch]
Ambra grisea
Liquid Ambra
Acacia
Macis
– – –
– – –
– – –
– – –
Terebinthina Veneta
Civet
– – –
– – –

Miscellanea

Agaric (3)
[Oak Galls] (9)
Corralina (9)
Muscus pixidatus (9)
Musc. e cran. human. mort. (11)
Terra Japonica (9)
Usnea (11)

Animal Substances

Drawer 4 (*mostly*)

[Boar's Tusk (11)]
[Cantharides]
Castorium
Cochineal
[Chelae Cancrorum (4 and 14)]
[Conchae]
[Cornu Cerv.] (15)
[Red Coral] (8)
Occul. Cancrorum
[Dentalium (8)]
[Fish's tail (14)]
[Ichthyocolla or Isinglass (11)]
[Os e cord. cerv. (8)]
Os Sepiae
[Otoliths of fish]
[Butterfly wing]
[Opercula of gastropod]
[Planorbis shell]

Mineral Substances, &c.

Drawers 6–10

Alumen Plumosum
[Amber] (6)
[Antimony sulphide] (10)
Arsenicum album (6)
,, flavum (6, 10, 9.)
,, rubrum (6)
Asbestos 4
Bezoar occidentalis
,, orient
Bismuth
Borax (6)
Chalcitis (6)
Cinnabar Persicum
[Copper ore] (6)
[Blue Copper carb.] (8)
[Galena] (6, 10, 14)
Lap. Granati
[Haematite]
[Obsidian]
[Ochre in pill-box, inscribed 'Harbord Cropley']
Ocra (9)
Papis osteocolla
Plumbum album
,, crudum
,, [metal sheet]
[Pumice] (10)
[Pyrites] (10)
[Quartz crystal]
Sal nitrum crudum
Sandevir (10)
[Selenite]
Sory
Sulphur nativum
,, vivum Wormianum (10)
Talcum
Terra sigillata flava (9)
Vitriolum album
,, Romanum
,, viride (10)

Fossils

Drawers 8–14

[Ammonite, 6-inch diam. (13)]
[Ammonite, small (14)]
Astroites Coral ab agro Northampton (8)
Inoceramus fragments
Belemnites (8)
[Fossil wood]
[12 Echini from the chalk, presumably of Cherryhinton]
[4 Micraster from the chalk]
[Numerous Terebratulas from the chalk]
[Encrinite rings]

Lapis Nephriticus. See p. 490.

APPENDIX E

LOAN EXHIBITION OF HISTORIC APPARATUS IN CAMBRIDGE 1936

A loan Exhibition of historic scientific apparatus, arranged under the auspices of the Cambridge Philosophical Society, was held in the East Room of the Old Schools in June 1936. It was opened at an evening reception on June 8 by Professor Lord Rutherford, whose address was reported in the *Cambridge Daily News* for June 9. He remarked that he was 'really surprised by the wealth of apparatus that has been dug out from the dug-outs of Cambridge', and after alluding in detail to some of the exhibits which illustrated the evolution of science, he added that 'steps should be taken to find a permanent suitable home for the more interesting and more historical part of it'. Certainly the keen interest of the visitors, who continued to come up to the very close of the exhibition, was most gratifying to the organizers.

The exhibits were listed in a printed Catalogue of thirty-two pages, the greater part of which was taken from this volume, but in addition there were shown a number of books, manuscripts, and portraits of scientific interest that were not included in the Catalogue.

Among the exhibits shown, which arrived too late to be mentioned in the appropriate places in this volume, were the following:

321. A representative collection of foreign **Portable Dials,** with a few English examples, recently received by the Fitzwilliam Museum from Mr. Charles Holden-White.

Examples of the signed work of the following makers are included in the collection.

English:—*H. C[ole]* 1576; *C. Whitwell*; *Elias Allen*; *Edm. Culpeper*; *Anthony Thompson* 1652; *A. W.* 1639.

French:—*Ch. Bloud* and *Eph. Senecal* of Dieppe; *Butterfield*; *Delur*; *Blondeau*; *Le Maire*; *Julien Le Roy*; *Felice Morelli*; *Macquart* and *H. Robert* of Paris.

German:—*David Beringer*; *Hans Ducher*; *T.D.*; *Johan Engelhardt*; *Engelbrecht*; *Johan Gebhart* 1556; *Conrad Karner*; *Udalricus Klieber* 1605; *Leonhart Miller* 1613–49; *Nicolaus Miller* 1649; *Paul Reinman*; *V. S.* 1576; *Hans Troschel* 1624.

322. **Selection of Slide-Rules** to illustrate the development of the instrument.

Prof. A. Hutchinson.

a. Circular Type derived from Oughtred's original model.
E.g. Halden's Calculex with principle scales arranged in a circle about 3·1 inches in diameter, Calculimètre Charpentier, and the Calculigraphe.

b. Linear Type derived from Gunter's Scale, first described in *De Sectore et Radio* 1623. The logarithmic scales of numbers, sines, and tangents are arranged parallel on a metal or wooden ruler: readings are made by dividers. The slide-rule was made by putting two such rules together so as to avoid the use of dividers, hence the early name of 'Sliding Gunter' for a slide-rule. Oughtred's 'Circles of Proportion' are Gunter's Scales 'bent or inflected into a circle with a radially moveable arm pivoted at the centre of the circle'.
Slide-rules with log log scales were introduced by Dr. Roget, F.R.S., in 1815.
E.g. Mannheim pattern made by Tavernier-Gravet, Faber, and later models.

c. Linear Type with multiple scales.
E.g. Cherry, Hannyngton 1884, Anderson made by Casella & Co., Cooper, Naish, and Thacher.
Naish's Logarithmicon 1898 was a divided scale instrument read by a moveable index. The scale is divided into 20 sections, each 4 inches in length repeated

4 times. The same principle is adopted in the Cherry, Proell, and Cooper instruments.

The Thacher has 20 scales each 18 inches long, fixed on a rotating frame inside which rotates and slides a graduated cylinder. It is equivalent to a slide-rule 30 feet long and gives results to 4 or 5 places of decimals.

The parallel scale type by Aston had 11 scales each 30 inches long.

d. Spiral Type. Lilly, Otis Calculator, and Fuller.

e. Slide-Rules devised for special purposes, e.g. Chemical Slide-Rules, Gaugers' Slide-Rules, such as Nos. 69–75.

323. Thomas Wright's Astronomical Models.

Lent by his great-grandson Dr. G. T. Bennett, F.R.S.

a. Tellurium by T. W.

b. Semissis or Semicircle for measuring Altitudes.

c. Cardboard Sextant, made by T. G. Wright, son of T. W.

These beautifully executed cardboard models illustrate the wide-spread and highly intelligent enthusiasm for scientific knowledge that was prevalent during the early part of the nineteenth century, when Mechanics Institutes were being opened in many parts of the country. Thomas Wright was also a highly accomplished musician.

324. Swedish Calendar Sticks. **1784.**

Lent by Mr. R. Holland-Martin.

Inscription on one incised, on the other in relief. They are said to be connected with an attempt made by a king of Sweden to perpetuate the Runic Calendar.

325. Armillary Sphere. **Early 19th cent.**

Lent by Mr. Foxwell of St. John's College.

Ingeniously constructed with printed paper circles, pasted on cardboard by a French maker.

326. Earl of Bute's Load-stone in silver case.
18th cent.

Lent by Mr. R. Holland-Martin.

Engraved: E^D Amory London Fecit.

$2\frac{1}{2} \times 3 \times 2$ inches.

327. Telephone Transmitter and Receiver. 1878.

Constructed by A. P. Trotter of Trinity, and used as one of a pair between the rooms of Dr. J. O. F. Murray and Charles A. E. Pollock when in residence in Trinity College.

328. Selection of Electrical Measuring Instruments.

Contributed from the Cavendish Laboratory.

ELECTROMETERS AND ELECTROSCOPES.

(i) Gravity controlled:

(*a*) **Early gold-leaf electroscope.** Used in Maxwell's time.
(*b*) **An original Wilson gold-leaf electroscope.** 1900.
(*c*) **Curie type gold-leaf electroscope.**
(*d*) **Wilson's tilted gold-leaf electroscope.** 1903.
(*e*) **The original Wilson universal gold-leaf electroscope.**
(*f*) **Kaye's tilted gold-leaf electroscope.** 1911.
(*g*) **Carmichael's tilted quartz-fibre electroscope.** 1933.
(*h*) **Thomson's electrostatic voltmeter.**
(*i*) **Capillary electrometer.**

(ii) Torsion controlled:

(*a*) **Thomson Quadrant electrometer.** *Elliott* 1880.
(*b*) **Thomson Quadrant electrometer.** *Elliott* 1884.
(*c*) **Thomson's attracted-disc absolute electrometer.**
(*d*) **Thomson's portable attracted-disc electrometer.**
(*e*) **Dolezalek Quadrant electrometer.**
(*f*) **Compton's Quadrant electrometer (Compton's original instrument).**
(*g*) **Lindemann electrometer.** Lent by *Cambridge Instrument Co.*

GALVANOMETERS.

(*a*) **Astatic galvanometer.** Used in Maxwell's time.
(*b*) **Thomson's Reflecting Galvanometer.** Possibly used in Maxwell's time.
(*c*) **Thomson's Reflecting galvanometer.**
Made by Prof. Stewart about 1884.

(*d*) **Thomson's Reflecting galvanometers. Astatic and non-astatic forms.**
(*e*) **d'Arsonval Moving Coil galvanometer. 1890.**
(*f*) **Modern instrument.**

Lent by *Cambridge Instrument Co.*

ATOMIC PHYSICS

329. Sir J. J. Thomson's Experimental Apparatus.

Cavendish Laboratory.

(1) Early X-ray bulbs.

(2) Apparatus used to determine the ratio of charge to mass for the electron.

(3) Parabola apparatus. [The first mass-spectrograph.]

330. Lord Rutherford's Experimental Apparatus.

Cavendish Laboratory.

(1) Apparatus used to determine ratio of charge to mass for the α-particle.

(2) Apparatus used to determine the charge on the α-particle.

(3) Apparatus used to show the identity of the α-particle and the helium nucleus.

(4) Apparatus used for the disintegration of nitrogen by α-rays.

PROFESSOR NUTTALL'S LOADSTONE.

HISTORIC APPARATUS IN THE ENGINEERING LABORATORY

332. Rose Engine Turning Lathe. **?18th cent.**

Inscribed upon the brass pulley wheel of the mandrel:

'The lathe formerly Sir Robert Frankland's; then of Admiral H. Selwyn is now given to Cambridge College. A.D. 1800; A.M. 5858.'

'Slide-rest eccentric by Mobois lathe over 400 years ago when entrée in French was spelt antrée.' [*Sic.*]

333. Engineering Models made for Professor Willis.

334. Water Motor.

Designed by Lord Rayleigh, and made in the Cavendish Workshops by Arthur M. Bewing, undergraduate of Caius College, 1879–81

335. Model of Watt's double-acting Beam Engine.

About 4 ft. 6 in. high on a base 3 ft. 6 in. long. Probably made in London for Prof. Willis.

336. Cylinder of a Newcomen Engine.

4-inch bore and 13-inch stroke with valve gear.

INDEX

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